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This thesis is a nontechnical overview of the Base Information Transfer System (BITS). It will discuss the history, current status and implementation of BITS, a subarchitecture of a broad Navy program created to support Department of the Navy communications ashore. The intent is to consolidate various sources regarding BITS into one document and to provide information to aid in understanding how BITS relates to base communications. The study will define the scope of BITS and will explore how BITS implementation will interface with other Navy, military, and worldwide communications systems. This thesis is intended as a broad, informational guideline and may also be used for students of naval communications and for orientation purposes.

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Base Information Transfer System
(BITS)

by

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from the

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ABSTRACT

The purpose of this thesis is to provide base Commanding Officers and communications managers with a non-technical overview of the Base Information Transfer System (BITS). This thesis discusses the history, current status and implementation of BITS, a subarchitecture of a broad Navy program created to support Department of the Navy communications ashore. The intent is to consolidate various sources regarding BITS into one document and to provide information to aid in understanding how BITS relates to base communications. The study defines the scope of BITS and examines its relationship to such global communications architectures as Copernicus.

This thesis also explores how BITS implementation will interface with other Navy, military, and worldwide communications systems. Separate chapters discuss how BITS implementation will influence acquisition, economics and equipment technology. This thesis also describes the functional transfer of Activities Providing Telephone Service (APTS) as an example of one level of the overall BITS subarchitecture. Finally, the authors' conclusions are presented, and areas of possible concern are identified.

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I. INTRODUCTION

A. PRESENT STATE OF BASE COMMUNICATIONS

Through the years, information and telecommunication systems on most naval bases developed independently. A variety of activities and departments, such as public works, supply, medical and personnel support, often planned and procured separate but similar stand alone systems. As technology improved and the need for such systems and related equipment expanded, many bases sprouted a mesh of redundant "spaghetti" networks. Experts and officials began to realize that it was more beneficial and cost effective, not to mention administratively easier as well as operationally necessary, to tie these separate systems together and to share common resources.

Throughout this thesis, *base communications* refers to a compilation of systems at any one base, ranging from existing standard telephone lines to local area networks (LANs) to data transfer systems such as video teleconferencing (VTC) or electronic mail (E-mail). Base communications are presently independent systems, each with unique missions. They often lack connectivity with similar systems. There is little coordination between activities located on the same base to capitalize on shared requirements and avoid duplication of

effort. Yet it seems clear that central coordination of all the communications and information systems on a base is necessary. Current communications connectivity is insufficient to meet present demands [Ref. 1:p. 9-2]. The older systems already in place are becoming obsolete and increasingly expensive to maintain.

To promote a more efficient employment of assets, the Navy has begun a restructuring of the communications and computer organization. In the April 1990 merger, the Naval Computer and Telecommunications Command (NAVCOMTELCOM) has been established as the central authority to manage assets that had formerly been under the control of different organizations. These assets include telephone systems, official message traffic, E-mail, automated data processing (ADP) and network management functions; in short, base communications. Making one organization responsible for a broader scope of communications operations should aid in reducing duplication of effort and encourage more standardization of systems.

B. PURPOSE, OBJECTIVES AND SCOPE

The purpose of this thesis is to provide the base communications officers and managers, the commanding officer (CO) and any action officers a non-technical overview of the Base Information Transfer System (BITS), a subarchitecture of a broad Navy program created to support Department of the Navy communications at the base level. This thesis will

discuss the history, current status and implementation of BITS. The objective is to provide the information needed to understand this subarchitecture as it relates to base communications. This thesis will explore how implementation of this system will influence acquisition, economics and current communications technology. This thesis will also describe the functional transfer of Activities Providing Telephone Service (APTS) as an example of one level of the overall BITS subarchitecture.

This thesis is designed to be used as a tool in understanding the BITS subarchitecture and its relationship to Navy-wide and worldwide communications. It may also be useful for general briefings and personnel indoctrination. This is intended as a broad set of guidelines, however, and will not provide a complete, detailed description of the technical aspects of BITS.

C. ORGANIZATION

This study is organized into chapters that discuss or analyze a specific aspect of BITS. Each will entertain certain questions and will pose new ones. BITS is an innovative concept that is still in a formative stage and is undergoing constant change.

Chapter II delves into the history of BITS. It introduces the reader to such larger communications concepts and architectures as the Naval Communications Control Architecture

(NCCA) and Copernicus, and describes where the BITS sub-architecture falls into place. This chapter also discusses the BITS concept and what the system is comprised of; the equipment and the technology. Appendix A of this thesis is an example of BITS as applied to any Navy base. It is a generic scenario using a fiber optic backbone. This appendix can be used by system designers or technical personnel for a more detailed understanding of the system.

Chapter III deals with the procurement and acquisition (strategy and process) of BITS; the history, the funding, the current status, and some possible concerns. It will discuss the Navy's life cycle management policy for information systems and how this applies to BITS. A project plan for BITS implementation will be described in detail. Also, the roles and responsibilities of key personnel and organizations concerning the successful acquisition of BITS will be delineated.

Chapter IV discusses economic issues associated with BITS. It will provide an analysis on whether leasing or buying equipment is the most cost effective method. A Lease Versus Purchase Analysis for the Administrative Telephone System at Oakland Army Base, and the Navy Leasing Feasibility Study are the foundation for a BITS analysis. This study can be used as a general guide for management personnel to use in determining lease versus buy for a specific base.

Chapter V deals with Activities Providing Telephone Service (APTS). It reviews and updates the functional transfer of these facilities to the NAVCOMTELCOM claimancy as part of the Navy-wide program for standardizing and integrating base communications.

Chapter VI discusses recommendations and conclusions. It will describe the pros and cons, the benefits and detriments, of BITS and how this sub-architecture will affect base communications. Questions and concerns for the future will also be raised.

II. NAVAL COMMUNICATIONS AND THE BITS SUBARCHITECTURE

A. SCOPE OF NAVAL COMMUNICATIONS

Naval communications today is fragmented, operations specific, relies on separate information systems and equipment for voice and data transmission and often utilizes out-dated or out-moded technologies. Because these systems were devised at a time when interconnectivity and interoperability were not a prime consideration, they generally lack both. Redundancy and repetition of function is the norm.

Communications (or *telecommunications*) as used in this thesis refers to all forms of optical or electronic information exchange. Two distinct theaters divide naval communications: ashore and afloat. In order to understand the intricacies of BITS, an examination of larger communications architectures and their relationship to BITS is necessary.

1. Naval Communications Control Architecture (NCCA)

a. Background and Purpose

Beginning in 1986, the Navy examined its data communications and discovered non-interoperable systems, lack of resource management, limited media capacity, diverse communications environments, and lack of central management. [Ref. 1:p. 8-4] To guide standardization, a top-level architecture was needed. In October of 1988, the Navy Data

Communications Control Architecture was published. Officials soon realized that such an architecture needed to encompass all of naval communications and not just data communications. The original architecture was rewritten. Currently, Navy officials, with help from the MITRE corporation, are drafting the sub-architectures and components of the renamed NCCA.

Developed as a single structure concept, the NCCA has the purpose of leading naval communications toward a "fully integrated, digital, standards-compliant network." [Ref. 1:p. 8-1]. The objective is to ensure complete Integrated Services Digital Network (ISDN) capability both afloat and ashore. Important aspects of this concept are responsiveness, cost-effectiveness, interoperability, reliability, adaptability and security.

b. Structure and Design

The NCCA, designed to meet operational, mission, and user needs, is to provide a variety of services. They include but are not limited to: file transfers, interactive transaction processing, imaging, voice, video-teleconferencing, and message services. The latter will be provided through the Defense Message System (DMS) described in detail in a separate section. Key considerations in developing communications systems must include: integration, interoperability, technological enhancement, and operational compatibility. Integration ensures that all communication

modes are capable of using all communications systems components (circuits, switches, terminal devices, etc.). Interoperability allows communications systems and related equipment to exchange information or services directly between them and their users [Ref. 2:p. 190]. Technological enhancement refers to how receptive a system is to innovation. The critical factor is operational compatibility. All communications systems must be able to successfully operate in all military scenarios and environments.

The NCCA is structured into two elements. The first describes distinct sub-architectures that provide a unique service to specified naval activities. Although separate in function, the binding factor is interoperability. The three sub-architectures of the NCCA shown in Figure 1 [Ref. 3:p. C-2] are: [Ref. 1:p. 8-11]

- BITS -- provides for an ISDN environment within naval bases and activities ashore.
- Afloat -- integrated systems aboard ships and the link of these systems to BITS ashore.
- Long Haul -- links of geographically separated naval activities and bases.

The second element of the NCCA describes the control components that apply throughout the sub-architectures. They each share a commonality of purpose. They are: network management, security, and standards and protocols. [Ref. 1:p. 8-2]

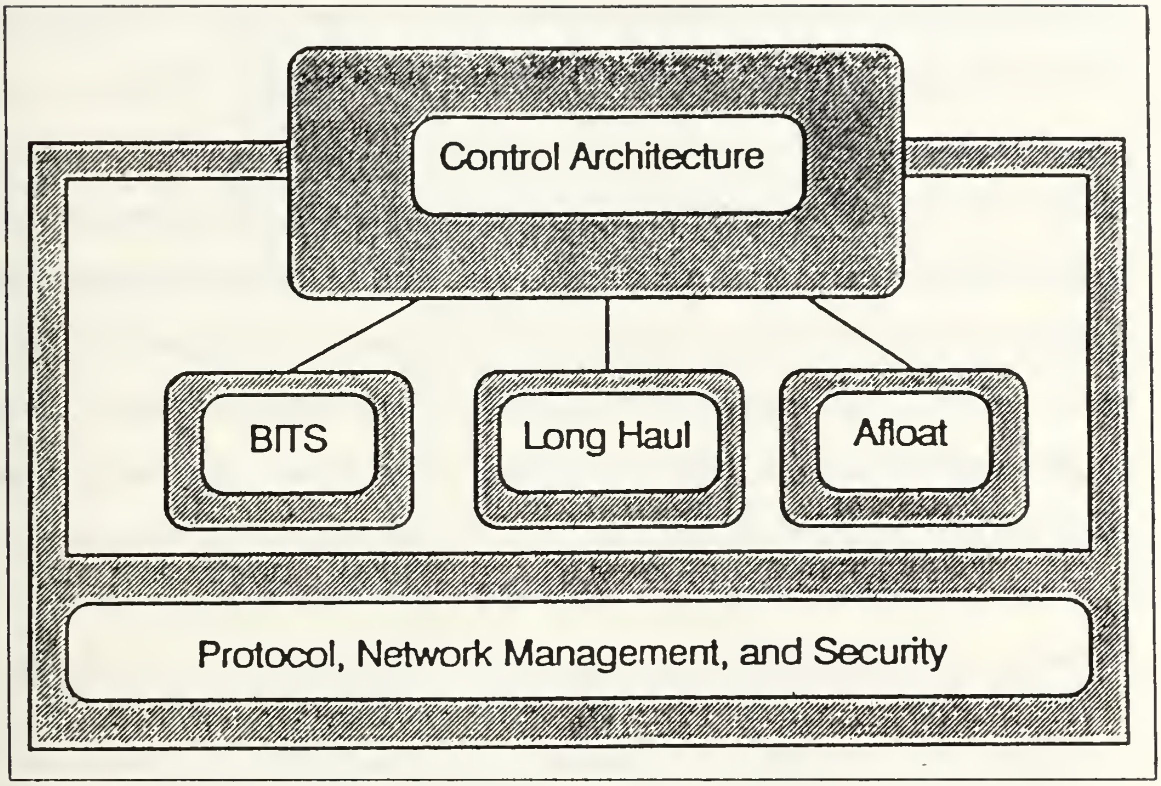

Figure 1. The Navy Communications Control Architecture

Overall responsibility for monitoring implementation and management of naval communications architectures lies with the Deputy Assistant Secretary for the Navy, Information Resource Management, DASN (IRM). NAVCOMTELCOM's responsibilities include "planning, configuration control, budgeting, material resource support, readiness, operations, maintenance, and management support" for BITS and Long Haul sub-architectures. The Space and Naval Warfare Systems Command (SPAWARSYSCOM) oversees the Afloat sub-architecture. Although DASN (IRM) has overall responsibility for the development and maintenance of the control components, NAVCOMTELCOM has hands on responsibility

for the network management component since it is an integral part of the BITS sub-architecture. [Ref. 1:p. 8-3]

2. Copernicus

Copernicus is a system architecture designed for the standardization and modernization of the Navy's command and control organization. Briefly describing this architecture demonstrates to the reader how BITS plays an important role in a global structure that affects naval and joint tactical operations worldwide.

a. Background and Purpose

> Naval command and control is the warfare function through which a maritime commander delegates warfighting responsibilities to subordinate commanders and their units under his command. Command and control is exercised through a supporting technological, doctrinal, and organizational system known today as C4I. [Ref. 4:p. 1-2]

Rapid advances in technology make "global surveillance" a real possibility. However, acquisition, management and operation of this technology requires a standard architecture. Copernicus is the architecture that will restructure and guide the Navy's command, control, communications, computers, and intelligence (C4I) strategy to better meet the demands of the post Cold War era.

C4I has evolved through three major phases. During World War II, command and control was organized into a system. Since World War II, technological advances have predominated and have grown out of proportion with the basic system

operation. The focus has turned to equipment capabilities vice operator needs. Systems have grown very complex with separate doctrines the rule. The number of communications networks has increased tremendously with the need to send all the globally accumulated data to the afloat tactical commander at sea. Today the effort is to "unite form with function" [Ref. 5:p. 86] and to balance the technology with system operation. To do so requires a major shift in perspective. The Copernicus architecture is designed to build the system around a common technology and centralized standards. The new center of perspective will be the operator vice the machine. [Ref. 5:p. 84]

b. Structure and Design

There are four basic cornerstones to the Copernicus architecture.

- Eight theater-wide Global Information Exchange Systems (GLOBIXS). Purpose: to acquire, standardize and concentrate shore-based data for Navy and joint use into "communities of like interests." [Ref. 4:p. 3-1].

- The Commander in Chief (CINC) Command Complex (CCC) is a virtual network. Purpose: to manage the information flow for the tactical commander.

- Fourteen Tactical Data Exchange Systems (TADIXS). Purpose: to exchange data information from GLOBIXS with data afloat.

- Tactical Command Center (TCC) afloat. Purpose: to make tactical use of data from the GLOBIXS-TADIXS information exchange.

c. *The BITS Interface*

Figure 2 illustrates the BITS interface within the Copernicus architecture [Ref. 4:p. 8-12]. The shore-based GLOBIXS networks will have a common intersection at the CCC. Each will be "carried over common bearer services, use common formats, and terminate in a common terminal" [Ref. 4:p. 4-20]. These networks will operate theater-wide or globally over the Defense Communications System or commercial systems. At the command center, bearer services will terminate at the BITS. Figure 3 highlights the elements of Copernicus and the BITS interface in a military scenario [Ref. 6].

> The Navy will use wireline bearer services for GLOBIXS, sharing access to the bearer for economy and efficiency. When ships and submarines are in port, they will access these bearers for limited TADIXS service. They will operate Support TADIXS message services in port just as they operate them at sea, using wireline bearer rather than SATCOM bearer service.
>
> Base Information Transfer System (BITS) will use wireless (e.g.,fiber optic) services to provide transfer of voice, data, and other formats within naval stations with interface to other bearer services (e.g.,DDN). Ships in port will be capable of BITS access for multiple services...[Ref. 4:p. 8A-15]

B. THE BITS CONCEPT

BITS came into being as technology advanced, standard communication protocols were identified, and integration of various information systems became feasible. Many sectors of society realized that potential savings existed by exploiting this technology to bring about more shared resources. The

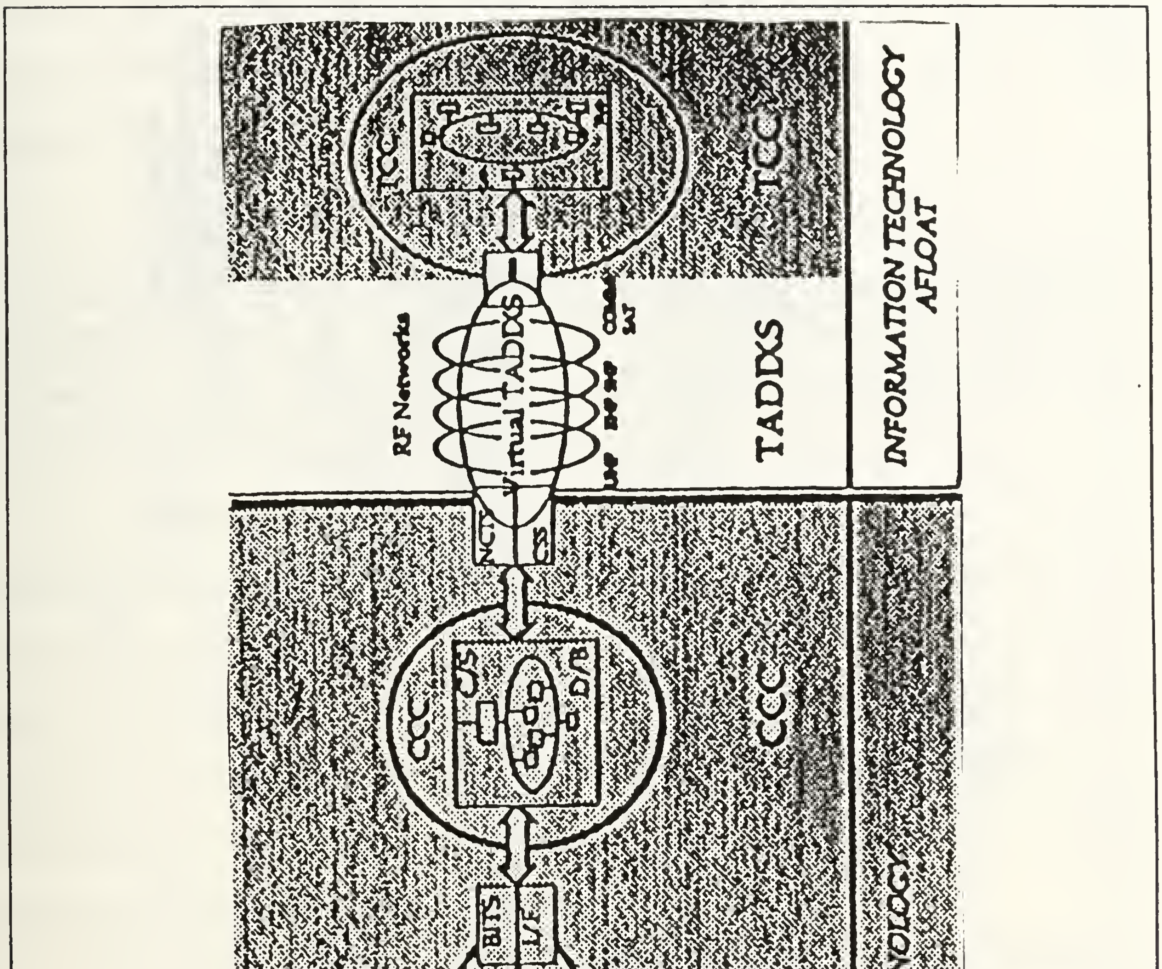

Figure 2. BITS Interface within Copernicus

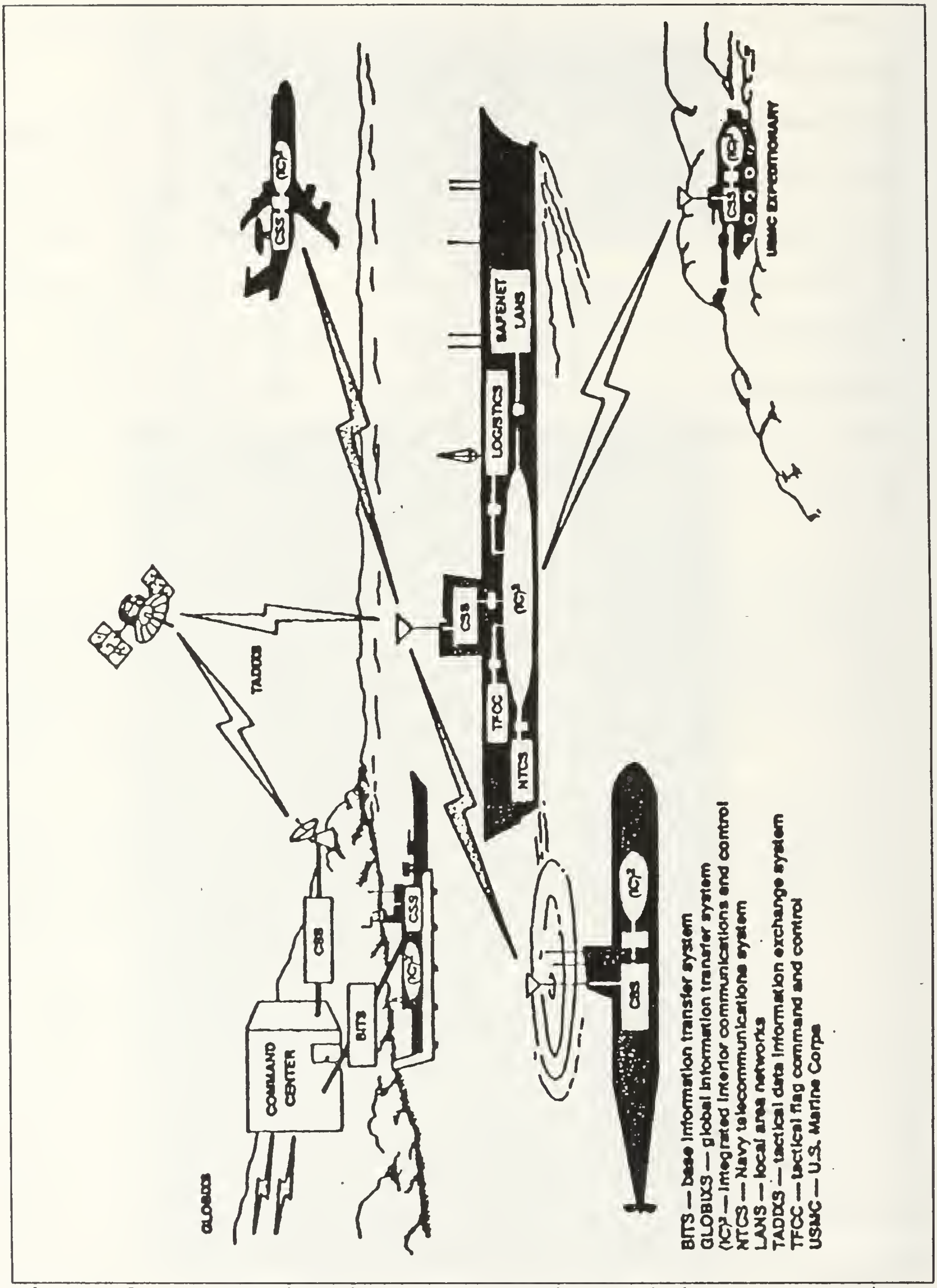

Figure 3. Communications Systems in a Military Scenario

Navy's plan to coordinate information flow in ashore facilities was conceptualized through the BITS subarchitecture.

> The Department of the Navy (DON) will embark on an innovative planning, management and procurement strategy to modernize base-wide communications. Considerations of limited resources, evolving technologies, and the current planning environment dictate that the DON must use a visionary approach to centralizing both planning and management. [Ref. 3:p. C-vi]

In order to accomplish these stated goals, the Navy has adopted an architecture that will allow interoperability of virtually all aspects of communications existing on any given base. This architecture will mandate interconnectivity of all systems on the base and allow a ship pulling into a pier to "plug into" the base system and connect with all the existing communication services.

To be able to accomplish integration, standardization is essential. The international community has been successfully working towards standardizing protocols in several areas. Open Systems Interconnection (OSI) defines protocols to ensure interoperability of information systems worldwide. Integrated Services Digital Network (ISDN), a subset of the OSI Reference Model, allows for the integration of voice, data, image, message, and video communication services using the telephone system as its foundation [Ref. 3:p. C-viii]. By adhering to these international standards, the DON will benefit, not only by the ability to integrate its own systems, but additionally

by being able to procure state of the art commercial off the shelf (COTS) communication equipment.

1. History and Background

In an effort to modernize information transfer systems, the Navy initiated a broad program in 1986. The objective was to utilize emerging technologies and adhere to standard protocols in order to overcome the deficiencies of current systems. The intention was to greatly improve the flow of information, thereby promoting more effective decision making and mission support capabilities to enhance mission readiness. [Ref. 3:p. C-1] BITS was created to support the communications of the DON by providing a coherent communications planning structure at the base level [Ref. 3:p. c-4]. It is a management strategy for the base commander to better utilize his/her communications assets. Interoperability and interconnectivity will exist for all equipment on the base, and there will be a central facility to coordinate all operational aspects of the system.

2. System Architecture

BITS is part of the Navy Communications Control Architecture (NCCA). It is an integrated communications architecture to provide voice, data, image, message, electronic mail, and video communication services to base users and ships at the pier. It will be comprised of:

- A backbone cable plant using a fiber-optic media.

- The base switch complex.
- A universal wiring scheme.
- A pier facility interface for ships.
- An interface for Defense Communication System (DCS) long-haul systems.
- Connectivity for the Defense Message System.
- A Network Management Center (NMC) to control and manage services.

The basic premise is that all base communications systems will be connected through the backbone cable, a fiber-optic system. [See Appendix A for an example of how BITS would be applied to a Navy base.] The backbone cable will provide the physical connectivity and electrical transmission between the users and the switch complex. Individual users will be connected based on a universal wiring scheme. The varying user equipment connected to the network must use approved, standard protocol suites (as set by OSI/ISDN). Networks that have dissimilar characteristics will require gateways or bridges. Existing local area networks (LANs) will have access to other LANs connected throughout the backbone cable plant. BITS will evolve to include a multi-level secure architecture. An important aspect of BITS is that it fully supports communication requirements at the pier. When in port, a ship will be able to utilize the full range of services available on the base. This will contribute to a fluctuation in usage of the overall BITS system, so it must be able to accommodate that, and allow for future expansion and

growth. By utilizing the high bandwidth capacity inherent in fiber optic media for the backbone cable, it will be possible to allow for a great deal of future growth without the need for installing additional cabling.

All users will be interfaced to the DCS long-haul networks through the base switch complex. Interbase data communications will primarily be accomplished through the Defense Data Network (DDN). Many of the DCS systems such as Automated Digital Network (AUTODIN) and Automatic Voice Network (AUTOVON) are currently changing, so the exact structure of the connectivity is not known at this point. Figure 4 provides a general overview of the BITS concept [Ref. 6].

a. Standard Protocols

The NCCA advocates that the Navy use OSI protocols. Protocols govern the rules and syntax that allow information to be transported through communications networks. In the past the military has used the unique Transmission Control Protocol/Internet Protocol (TCP/IP) resulting in limited interoperability outside of the Department of Defense (DOD). To gain flexibility and universal interoperability, migration to the widely accepted OSI protocols will occur.

b. Services Offered in BITS

The following services will be available to all the system users on the base or at the pier:

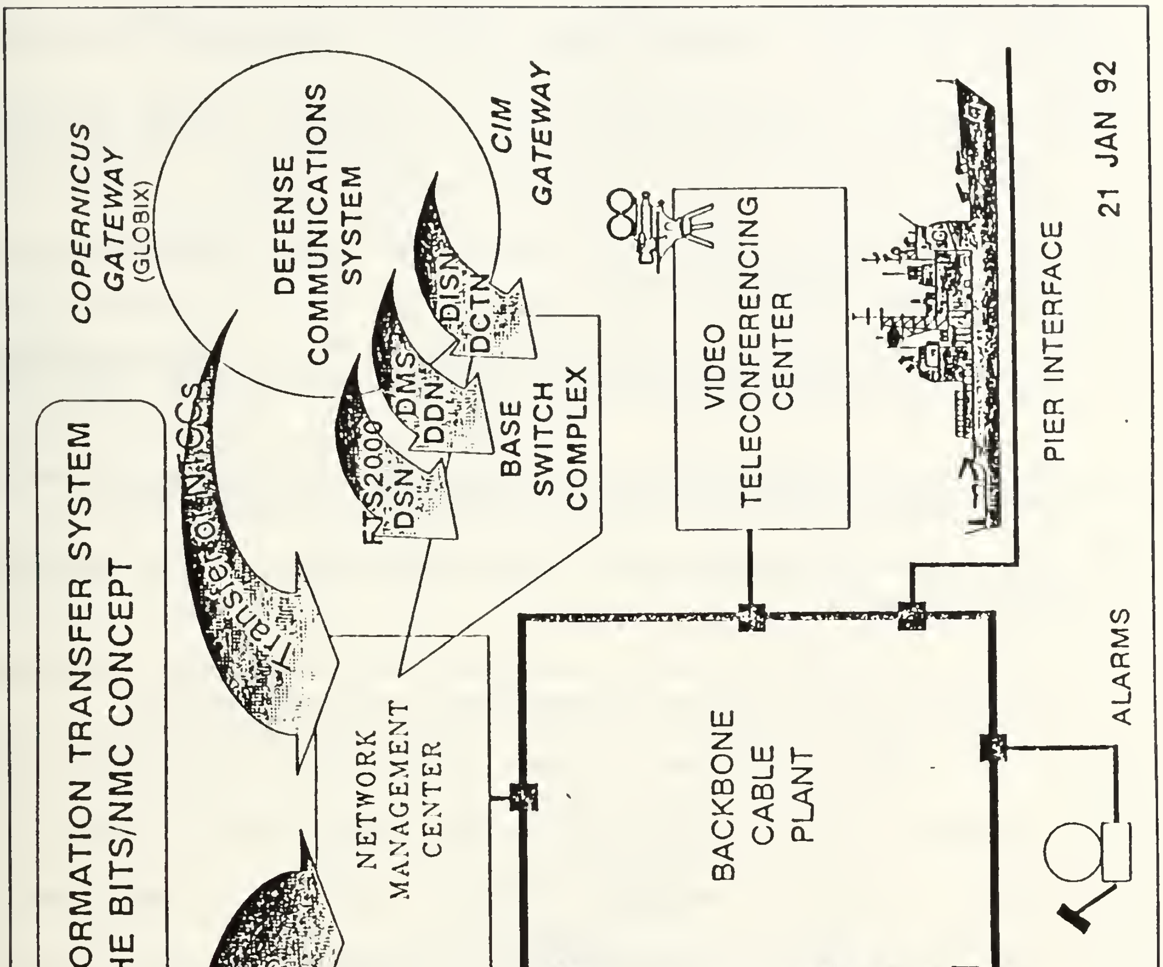

Figure 4. Overview of the BITS Concept

- File Transfer--to send and receive large volumes of raw data or reports from one location to another.
- Interactive Mode--used when a terminal user or host computer process desires real time information from and immediate interaction with a host processor.
- Message Communications--encompasses record communications, DDN, and electronic mail.
- Video Teleconferencing--interactive, electronically conducted meetings between different locations, this will be a shared facility.
- Imaging--the representation, storage, and access of images reproduced electronically or by optical means.
- Security--the system will allow for a variety of security requirements.
- Voice Communications--includes all existing features including multi-level precedence and preemption.

These services currently exist on many bases. The BITS concept will allow for more efficient use of assets and provide an overall management for all the communication services described. The central management facility will be the NMC.

3. Management Structure of System

The NMC will be the focal point for all administration, operation, and maintenance of BITS as well as for user services and resolution of user complaints. It is based on the guiding principle of unification of communications management. The NMC will coordinate with the users of the system as well as the technical control facility, the base switch complex, long-haul networks and interfaces to ships at pierside. It will contain state of the art displays,

interactive databases, monitoring, control, and planning aids to administer and plan all communications on a base. [Ref. 1:p. 9-4]

The NMC will serve as the single point of contact where users can get virtually all of their communications problems resolved. Figure 5 [Ref. 3:p. C-47] provides a detailed description of the NMC.

Functions of the NMC can be broadly classified as follows. [Ref. 3:p C-B-9] While this is not an all-inclusive

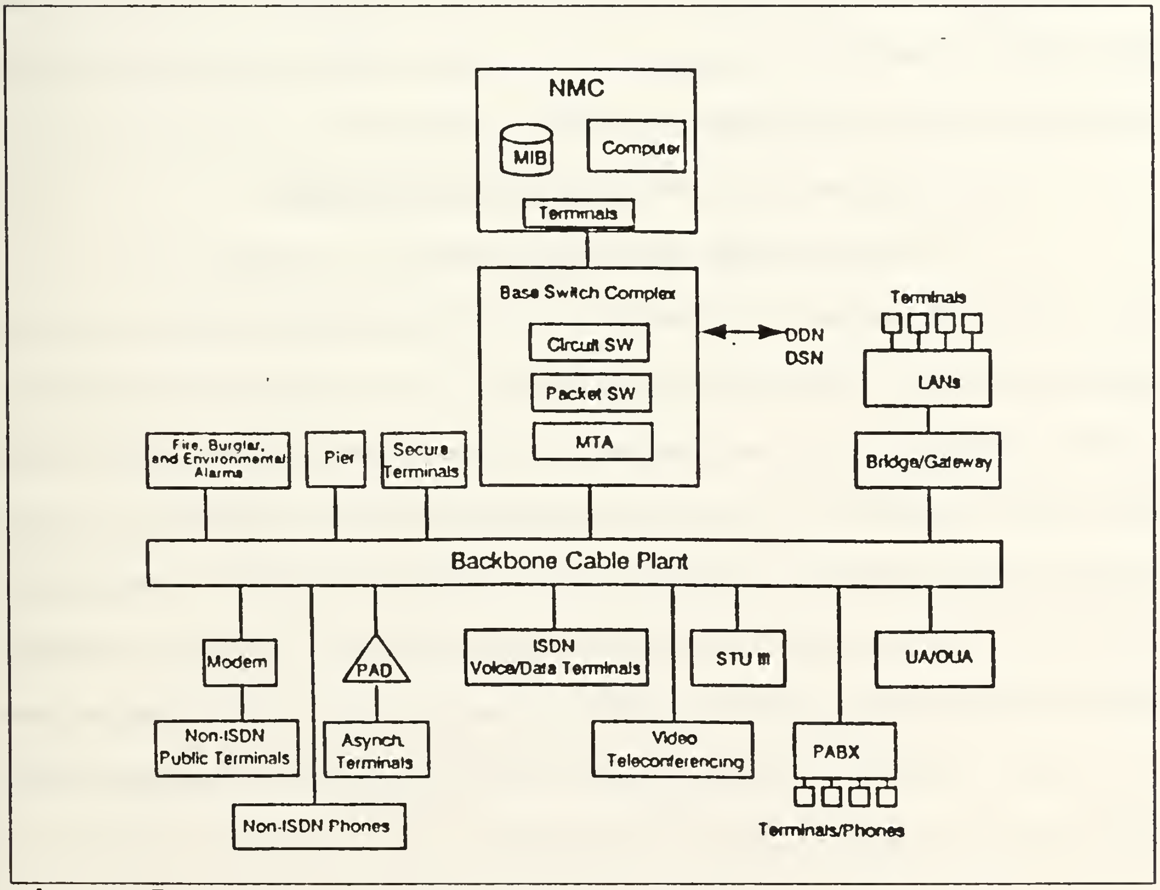

Figure 5. Network Elements Managed by the Base NMC

list, it serves to categorize the primary functions of the NMC:

- Fault Management--includes all aspects of dealing with fault detection, diagnosis, and resolution.
- Performance Management--involves data collection and analysis.
- Configuration Management--includes identifying the locations and types of user equipment; provides access control and authorization data.
- Security Management--manages authentication, access control and encryption facilities.
- Accounting Management--provides user administration and accounting data processing.

For the NMC to effectively manage BITS, it must interface with external (off base) communications systems. The NMC is designed to support and provide the communication protocols and interfaces needed.

4. Interfaces With Other Systems/Networks

a. *Defense Data Network (DDN)*

As a major subsystem of the Defense Communications System (DCS), the DDN provides long haul transmission capability. A digital packet switched network, it allows for worldwide operational coverage and support. DDN will provide the long haul communications connectivity for BITS. For those bases with access to a network node, BITS will gain entrance to DDN through a specific DDN gateway. For those bases with no direct node access, BITS will provide dial-up connectivity. Users with unclassified information will connect through the

Military Network (MILNET) portion of DDN. The Defense Integrated Secure Network (DISNET) will be used for classified information. Traffic will be encrypted at the originator's work station and decrypted at the distant end.

DDN will evolve towards Open Systems Interface (OSI) standard protocols. However it will maintain the capability of utilizing Transmission Control Protocol/Internet Protocol (TCP/IP) based systems until complete conversion takes place. The Defense Commercial Telecommunications Network (DCTN) will augment DDN when necessary. A leased communications system operated by Defense Information Systems Agency (DISA), DCTN provides such services as routine common-user switched voice, dedicated voice or data, and video-teleconferencing throughout the United States. [Ref. 4:p. 4-24]

b. Defense Switched Network (DSN)

If BITS loses access to DDN, possibly through war or natural disaster, the DSN will be used as an alternate means of providing data communications service [Ref. 1:p. 9-13]. The primary telecommunications network for the Department of Defense (DOD), DSN has evolved from the existing AUTOVON system. DSN will provide multi-level precedence and pre-emption for clear and secure voice services. ISDN technology is the target for this system.

BITS will interface with DSN through switches and nodes. BITS users will then have such services available to them as: [Ref. 1:p. 9-13].

- Dial-up connectivity to DDN.
- Augmentation of DDN data communications service.
- Video teleconferencing service.
- Usage-based billing.

c. Federal Telecommunications System 2000 (FTS 2000)

On the horizon, FTS 2000 is planned to meet the telecommunication needs of the federal government beyond the year 2000. It will consist of a multi-services contract providing the government with a network for switched voice services, switched data services, packet-switched services, E-mail, video transmission and dedicated transmission services. FTS 2000 will carry administrative traffic only. Tactical communications which includes cryptographic traffic and C4I traffic will not be carried by FTS 2000.

d. Defense Message System (DMS)

DMS provides flexible store and forward messaging service. The system currently consists of AUTODIN and E-mail. By the year 2000, the goal of DMS is to provide secure desktop to desktop service that will phase out AUTODIN and most telecommunications centers.

A gateway will provide connectivity between BITS and the long haul DMS network. Messaging services offered by

DMS include organizational messaging. Such traffic includes command and control messages or any other messages that require authority approval before transmission. BITS will provide the connectivity between the Message Transfer Agents (MTAs) and the Organization User Agent (OUA) for the successful transmission of these types of messages. Informational messaging is also a service of DMS. Administrative messages and working communications between individuals fall into this category. BITS will provide the connectivity between the MTAs and the User Agents (UAs) involved in informational messaging.

e. Corporate Information Management (CIM)

The CIM plan is a management initiative calling for the development of standard information systems throughout the Department of Defense for common functional areas such as payroll, personnel issues, medical coverage and logistics [Ref. 7:p. 17]. This concept considers information a valuable resource that needs to be manipulated efficiently to obtain cost savings. CIM is important because it centralizes information functions and management using open systems architecture. BITS will easily integrate into this system both physically and conceptually. Refer to Figure 4 as an illustration of the interconnectivity between BITS and DDN, DSN, DMS and the CIM gateway.

III. PROCUREMENT PROCESS FOR BITS

A. DEPARTMENT OF THE NAVY ACQUISITION REGULATIONS

In an effort to better coordinate the limited resources of the Department of the Navy, the Life Cycle Management (LCM) Policy and Approval Requirements for Information System (IS) Projects was issued as Secretary of the Navy Instruction (SECNAVINST) 5231.1 on 8 March 1985. The regulations apply to various types of information technology and management of information systems. SECNAVINST 5231.1 is an adaptation of the system acquisition management process which is described in SECNAVINST 5000.1B and DOD 5000.1. LCM is a management discipline for acquiring and using IS resources in a cost-effective manner throughout the entire life of a system. [Ref 8]

1. Applicable systems

The scope of the systems involved are as follows:

- ISs primarily supporting administrative or logistics functions (BITS falls into this area).
- ISs primarily supporting research, development, test and evaluation (RDT&E).
- ISs **not** designated as major systems by the Secretary of Defense.
- ISs **not** primarily supporting Weapons, Command and Control, Communications in direct support of military operations, or Intelligence in direct support of military operations.

2. Life Cycle Management (LCM) Goals

The goal of the LCM for IS projects is to support the mission by providing systems that demonstrate the following:

a. Effectiveness

Information required to perform assigned tasks must be available: when needed, with accuracy, in the most usable form, to those who need it and only to the appropriate people.

b. Affordability

The IS must collect, refine, combine, communicate, store and retrieve information at an acceptable cost in terms of both dollars and personnel.

c. Efficiency

The system must achieve maximum benefit at a minimum cost. Each item of information should be necessary for mission accomplishment, and retained in only one place, unless multiple storage is required for security or for more economic use.

d. Manageability

The system must provide indicators to identify conditions that are out of the acceptable limits. These limits must be defined qualitatively and quantitatively. Procedures must exist for system problem diagnosis and performance verification so that managers can take appropriate corrective action.

e. *Coordination*

The IS must be integrated with all other ISs with which it must interact. It will be consistent with all applicable standards for data, information technology, and information systems.

3. Life Cycle Management Phases

IS projects must be managed in accordance with a five phase LCM strategy. [Ref. 8:p. 2 of encl (4)]

a. *Mission Analysis and Project Initiation Phase*

The purpose of this phase is to identify and validate a mission element need, determine specific assumptions and recommend consideration of alternative concepts of an information system to satisfy the need. It is in this phase that management determines if a valid mission deficiency or opportunity exists. A Mission Element Need Statement (MENS) will be compiled to provide a succinct statement of the problem or opportunity, its importance, and any significant time, cost, or other constraint that could apply to exploration and acceptance of alternative solutions to the mission need. The estimated total costs must be identified as completely and accurately as possible. When feasible, it is stressed that mission needs should be satisfied by using existing resources.

b. *Concept Development Phase*

At this point, alternative ways to satisfy the MENS will be developed and evaluated. Initial economic analysis of alternative solutions are performed, and recommendations of one or more feasible concepts are made for further consideration. Management will examine the MENS and determine if several competing concepts should be demonstrated and the risks associated with each. A Project Manager will be appointed, and a Project Management Plan will be prepared to identify organizational relationships and responsibilities for management and support of the IS project during each remaining phase of the system life cycle. Finally, a System Decision Paper at Milestone I (SDP-I) will be approved to recommend one or more workable solutions for detailed evaluation.

c. *Definition and Design Phase*

Detailed functional requirements for information system performance will be defined and validated. Alternative designs for an operable IS will be evaluated as to implement the recommended concepts. Economic analyses of the alternatives will be further refined and the most cost effective design for full scale development will be recommended. Once the best system is selected and its technical adequacy verified, an SDP at Milestone II is approved (SDP-II).

d. *System Development Phase*

The purpose of this phase is to develop, integrate, test and evaluate an operable information system to satisfy the information system specifications and update the economic analysis for the operational system. The system will be field tested and a training plan and an IS integrated logistics support plan developed. Finally, an SDP-III is approved indicating that the system is ready to be implemented.

e. *Deployment and Operation Phase*

In this phase, deployment and operation of the system occurs in accordance with specifications. Implementation plans, including training and resource availability, must be sufficient to support the schedule for operations prior to approving the SDP-IV. That approval indicates that system performance is acceptable.

B. BITS ACQUISITION

NAVCOMTELCOM is responsible for the integration and consolidation of ashore communications within the Department of the Navy (DON) [Ref. 9:p. 2]. NAVCOMTELCOM will provide technical standards for base telecommunications services, replacement of equipment, and upgrading of existing base communications [Ref. 10:p. 1]. BITS is the solution to integrate base communications and information systems.

1. Acquisition Strategy

NAVCOMTELCOM has developed an acquisition strategy to ensure compliance with higher level directives and facilitate the process. This strategy defines how the acquisition process will be employed.

a. *Sources*

Many of the products (i.e., communications equipment) that will be procured for the BITS program will be commercial off the shelf technology (COTS) for which there exists a broad vendor base. This enables both small and large firms to become suppliers for the system.

b. *Competition*

There is a great emphasis on competition among suppliers. It will be sought, promoted and sustained throughout all program years [Ref. 9:p. 12]. Required specifications for BITS have been written only after consultation with vendors in order to simplify the procurement process.

c. *Source selection*

Competitive negotiations will be used and contracts awarded to responsive and responsible offerors deemed acceptable in all evaluated areas [Ref. 9:p. 12].

d. *Contracts*

Because the majority of the items will be COTS, contracts will be firm fixed price [Ref. 9:p. 12].

Solicitations will be issued in accordance with Title VII of the Deficit Reduction Act of 1984, Public Law 98-369, and the Competition in Contracting Act.

2. Acquisition Process

To make the transition to BITS as simple as possible, NAVCOMTELCOM has contracted Booz, Allen, and Hamilton, Inc. to create an acquisition process and implementation plan to be used Navy-wide. The end result, a Project Implementation Plan (PIP), will be used by base commanders and action officers as a project guideline. The objective of the PIP is to describe the processes to execute BITS in detail and define the roles and responsibilities of key personnel [Ref. 11:p. 3].

SECNAVINST 5231.1 permits project managers to tailor the execution of a project to suit the unique characteristics of that project. The PIP uses a streamlined, three phase approach to LCM of BITS which satisfies the regulations required in SECNAVINST 5231.1. Each phase includes a general description and estimated timeline for accomplishment. Within these three phases are a total of 50 project functions described in detail that must be undertaken. Table 1 lists each of these functions and the organizations responsible for them.

a. The Mission Analysis and Project Initiation Phase

Within this phase, the Activities Providing Telephone Service (APTS) will determine specific requirements

Table I Project Functions

FUNCTION	LEAD	DEVELOPMENT INPUT	REVIEW	APPROVAL
MISSION ANALYSIS AND PROJECT INITIATION PHASE				
1. INITIAL REQUIREMENTS IDENTIFICATION	APTS	ECHELON III NAVCOMTELCOM	ECHELON III	NAVCOMTELCOM
2. DETERMINE INVESTMENT STRATEGY	APTS	ECHELON III NAVCOMTELCOM	NAVCOMTELCOM MAJOR CLAIMANT	RESOURCE SPONSOR
a. ESTIMATE COSTS	APTS	ECHELON III	ECHELON III	NAVCOMTELCOM
b. IDENTIFY FUNDING	APTS	ECHELON III NAVCOMTELCOM	NAVCOMTELCOM MAJOR CLAIMANT	RESOURCE SPONSOR
3. LIFE CYCLE MANAGEMENT	APTS	ECHELON III	ECHELON III > $25K NAVCOMTELCOM > $1M NISMC > $10M	ECHELON III < $1M NAVCOMTELCOM < $10M NISMC < $250M
a. ABBREVIATED SYSTEM DECISION PAPER (ASDP)	APTS	ECHELON III	ECHELON III > $25K NAVCOMTELCOM > $1M NISMC > $10M	ECHELON III < $1M NAVCOMTELCOM < $10M NISMC < $250M
b. AGENCY PROCUREMENT REQUEST (APR)	APTS	ECHELON III NAVCOMTELCOM	NAVCOMTELCOM NISMC	NISMC < $2.5M GSA > $2.5M
c. WARNER DETERMINATION	APTS	ECHELON III NAVCOMTELCOM	NISMC	NISMC
4. COMMANDING OFFICER IN-BRIEF	NAVCOMTELCOM	ECHELON III APTS	ECHELON III NAVCOMTELCOM	NAVCOMTELCOM
SYSTEM DEVELOPMENT PHASE				
5. ACQUISITION PLAN	CONTRACTING ACTIVITY	NAVCOMTELCOM	CONTRACTING ACTIVITY NAVCOMTELCOM	CONTRACTING ACTIVITY
6. APPOINT CONTRACT PLANNING COUNSEL MEMBERS	CONTRACTING ACTIVITY	NAVCOMTELCOM		
7. CONDUCT CONTRACT PLANNING CONFERENCES	CONTRACTING ACTIVITY	APTS ECHELON III NAVCOMTELCOM		
8. SCHEDULE ACQUISITION EVENTS	CONTRACTING ACTIVITY	APTS ECHELON III NAVCOMTELCOM		CONTRACTING ACTIVITY
9. PREPARE SITE SPECIFIC REQUIREMENTS	APTS	ECHELON III	ECHELON III	ECHELON III < $100K NAVCOMTELCOM < $100K
10. PREPARE REQUIREMENTS PACKAGE	CONTRACTING ACTIVITY	ECHELON III NAVCOMTELCOM APTS	ECHELON III	NAVCOMTELCOM
11. DETERMINE CONTRACT AND LEGAL SUFFICIENCY	CONTRACTING ACTIVITY		COMPETITION ADV. GENERAL COUNSEL	CONTRACTING ACTIVITY
12. PREPARE COMMERCE BUSINESS DAILY NOTICE	CONTRACTING ACTIVITY	ECHELON III NAVCOMTELCOM	ECHELON III < $100K NAVCOMTELCOM > $100K	CONTRACTING ACTIVITY
13. APPOINT TECHNICAL EVALUATION GROUP MEMBERS	CONTRACTING ACTIVITY	APTS ECHELON III NAVCOMTELCOM	NAVCOMTELCOM	CONTRACTING ACTIVITY

FUNCTION	LEAD	DEVELOPMENT INPUT	REVIEW	APPROVAL
14. APPOINT BUSINESS EVALUATION PANEL MEMBERS	CONTRACTING ACTIVITY			
15. PREPARE CONTRACT SECTIONS AND ASSEMBLE RFP	CONTRACTING ACTIVITY			
16. PREPARE IGCE	ECHELON III < $100K NAVCOMTELCOM > $100K			NAVCOMTELCOM
17. ISSUE REQUEST FOR PROPOSAL	CONTRACTING ACTIVITY			
18. CONDUCT PRE-PROPOSAL CONFERENCE	CONTRACTING ACTIVITY	APTS ECHELON III NAVCOMTELCOM	APTS ECHELON III NAVCOMTELCOM	
19. CONDUCT SITE VISITS	NAVCOMTELCOM	APTS ECHELON III NAVCOMTELCOM		
20. PREPARE QUESTIONS AND ANSWERS	CONTRACTING ACTIVITY	APTS ECHELON III NAVCOMTELCOM	NAVCOMTELCOM	CONTRACTING ACTIVITY NAVCOMTELCOM
21. RECEIVE INITIAL PROPOSALS	CONTRACTING ACTIVITY			
22. CONDUCT TECHNICAL EVALUATION	CONTRACTING ACTIVITY	APTS ECHELON III NAVCOMTELCOM	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K	CONTRACTING ACTIVITY
23. CONDUCT BUSINESS EVALUATION	CONTRACTING ACTIVITY			CONTRACTING ACTIVITY
24. PRE-BUSINESS CLEARANCE	CONTRACTING ACTIVITY			CONTRACTING ACTIVITY
25. ISSUE DEFICIENCIES	CONTRACTING ACTIVITY	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K
26. REVIEW RESPONSES / REVISE RESPONSES	CONTRACTING ACTIVITY	APTS ECHELON III NAVCOMTELCOM	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K	CONTRACTING ACTIVITY
27. EVALUATE TECHNICAL REVISIONS	CONTRACTING ACTIVITY	APTS ECHELON III NAVCOMTELCOM	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K	CONTRACTING ACTIVITY
28. EVALUATE BUSINESS REVISIONS				
29. DETERMINE COMPETITIVE RANGE	CONTRACTING ACTIVITY			CONTRACTING ACTIVITY
30. DISCUSSIONS	CONTRACTING ACTIVITY	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K		CONTRACTING ACTIVITY
31. REQUEST BEST AND FINAL OFFERS (BAFO)	CONTRACTING ACTIVITY			CONTRACTING ACTIVITY
32. RECEIVE BAFO	CONTRACTING ACTIVITY			CONTRACTING ACTIVITY

FUNCTION	LEAD	DEVELOPMENT INPUT	REVIEW	APPROVAL
33. EVALUATE BAFO TECHNICAL REVISIONS	CONTRACTING ACTIVITY	APTS ECHELON III NAVCOMTELCOM	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K	CONTRACTING ACTIVITY
34. EVALUATE BAFO BUSINESS REVISIONS	CONTRACTING ACTIVITY			CONTRACTING ACTIVITY
35. POST BUSINESS CLEARANCE	CONTRACTING ACTIVITY			CONTRACTING ACTIVITY
36. AWARD CONTRACT	CONTRACTING ACTIVITY	APTS ECHELON III NAVCOMTELCOM		CONTRACTING ACTIVITY
37. NOTIFICATION OF AWARD / CONTRACT DISTRIBUTION	CONTRACTING ACTIVITY			CONTRACTING ACTIVITY
38. CONTRACTOR SITE SURVEY	CONTRACTING ACTIVITY	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K		
39. NEGOTIATIONS AND CONTRACT MODIFICATIONS	CONTRACTING ACTIVITY	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K	CONTRACTING ACTIVITY
40. ENGINEERING CHANGE PROPOSAL	CONTRACTING ACTIVITY	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K	CONTRACTING ACTIVITY
41. VALUE ENGINEERING	CONTRACTING ACTIVITY	APTS ECHELON III NAVCOMTELCOM	PER REGULATION	PER REGULATION
42. NEGOTIATE/EXECUTE CONTRACT MODIFICATION	CONTRACTING ACTIVITY	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K	CONTRACTING ACTIVITY
43. QUALITY ASSURANCE	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K	AUTHORITY CITED IN BLOCK 6 OF THE APPROPRIATE DD FORM 1423
44. TEST AND ACCEPTANCE	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K
45. CONTRACT DELIVERABLE ACCOUNTING	CONTRACTING ACTIVITY	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K	AUTHORITY CITED IN BLOCK 6 OF THE APPROPRIATE DD FORM 1423
46. INITIAL OPERATIONAL CAPABILITY (IOC)	COTR	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K	AUTHORITY CITED IN BLOCK #8 OF CDRL A028
47. FULL OPERATIONAL CAPABILITY (FOC)	CONTRACTING ACTIVITY	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K	AUTHORITY CITED IN BLOCK #6 OF CDRL A028
DEPLOYMENT AND OPERATION PHASE				
48. CONTRACT PAYMENT	CONTRACTING ACTIVITY			CONTRACTING ACTIVITY
49. EXERCISE OPTIONS	CONTRACTING ACTIVITY	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K	APTS < $25K ECHELON III < $100K NAVCOMTELCOM > $100K	CONTRACTING ACTIVITY
50. CONTRACT CLOSEOUT	CONTRACTING ACTIVITY			CONTRACTING ACTIVITY

for the modernization of the base communications systems. A critical step, setting requirements, determines the path that the rest of the procurement process will follow. Objectives for BITS implementation will be set and resources obtained. Adequate manpower, materials and money to satisfy the requirements must be secured. This is often accomplished through a Program Objective Memorandum (POM). Early action is recommended as this is a lengthy process. At this time LCM procedures and documentation will be established to allow for proper planning of the project. Technical requirements will be set in an Abbreviated System Decision Paper (ASDP) and assessed. Major milestones and functions of the assessment phase are expected to be completed within three to six months and include [Ref. 11:p. 20]:

- Complete initial requirements identification.
- Complete LCM documentation.
- Submit Agency Procurement Request (APR) for Navy approval.
- Submit APR to General Services Administration (GSA).

b. The System Development Phase

This phase encompasses the heart of the acquisition process. During this period, the base CO will prepare the formal acquisition documents that state the requirements and strategy necessary for BITS. A BITS Project-Specific Strategy for Execution will be developed [Ref. 12:p. 2]. Key players within the organization will be identified by name for

procurement execution. Actions during this phase of the BITS implementation process include, but are not limited to:

- Preparing an acquisition plan and scheduling acquisition events.
- Preparing and validating BITS requirements packages.
- Preparing a contract data requirements list (CDRL), a statement of work, a performance work statement, contract line item numbers (CLIN), security documentation, cost model and the Commerce Business Daily notice.

The next step within this phase is to perform all the tasks necessary to award a contract. Offerors will visit the site to help formulate a proposal. All proposals deemed reasonable will be included in the competition. Contracts will be awarded after a thorough evaluation. The major milestone in this portion of the System Development Phase will include:

- Issuing the Request for Procurement (RFP).
- Appointing contracting planning counsel members and conducting a contract planning conference.
- Conducting site visits.
- Receiving proposals.
- Completing initial evaluations and determining a competitive range.
- Receiving Best and Final Offers (BAFOs).
- Awarding a contract.

Once the contract is awarded, the emphasis is placed on getting the system installed at the base. The Contracting Officer's Technical Representative (COTR) at the APTS site will monitor contractor compliance. Any new

technical specifications will be accomplished through an Engineering Change Proposal (ECP) coordinated between the base CO and the contractor.

Finally, testing is accomplished within this phase. There are three types of tests: contractor verified, government verified, and a 30 day acceptance test. Once an IS passes the first two tests, it is declared to have an Initial Operational Capability (IOC) and will be evaluated in the actual operational environment. When all tests are successfully completed and the system is declared Full Operational Capability (FOC), this phase is complete. The time frame of the entire phase can be expected to vary from 30 to 33 months.

c. *The Deployment and Operations Phase*

This final phase encompasses the operation and maintenance of the BITS until it is either upgraded or retired. Contract payments and execution of options in the contract occur here.

C. ROLES AND RESPONSIBILITIES OF KEY PERSONNEL

To ensure the successful acquisition, procurement, and implementation of BITS per base and throughout the Navy, specific delineation of organizational roles and responsibilities is vital. Adherence to such responsibilities by each key participant is also crucial for a smooth transition and modernization of Navy base communications.

1. Chief of Naval Operations (CNO)

The Director, Space and Electronic Warfare (OP-094) is "the principal advisor to the CNO on command and control matters and ensures optimum use of Navy information systems." [Ref. 13:p. 26]. This office is the Navy functional sponsor for C4I. OP-094 has designated NAVCOMTELCOM as the program functional manager for BITS.

2. Commander, NAVCOMTELCOM

As the functional manager, NAVCOMTELCOM will serve as the central clearing house and single systems manager for BITS and has the LCM procurement authority for one to ten million dollars [Ref. 14]. NAVCOMTELCOM will collect, forward and disseminate all required BITS acquisition documentation to and from the Echelon III activities, the Navy Information Systems Management Center (NISMC) and the Information Technology Acquisition Center (ITAC). This office will resolve all BITS LCM issues with NISMC, ITAC, CNO and the Naval Supply Systems Command (NAVSUPSYSCOM). In addition, NAVCOMTELCOM will provide oversight, guidance and assistance, as well as the following functions:

- Serve as LCM clearinghouse.
- Serve as configuration manager for BITS.
- Provide oversight and technical assistance.
- Act as the base advocate at the contracting activity.
- Review and approve procurement actions.

- Coordinate delegations of authority.

3. Echelon III Commands

The following ten Echelon III activities have been identified [Ref. 14]:

- Naval Computer and Telecommunications Area Master Station, Western Pacific (NCTAMS WESTPAC).
- Naval Computer and Telecommunications Area Master Station, Eastern Pacific (NCTAMS EASTPAC).
- Naval Computer and Telecommunications Area Master Station, Atlantic (NCTAMS LANT).
- Naval Computer and Telecommunications Area Master Station, Mediterranean (NCTAMS MED).
- Naval Computer and Telecommunications Station, San Diego.
- Naval Computer and Telecommunications Station, Jacksonville.
- Naval Computer and Telecommunications Station, Pensacola.
- Naval Computer and Telecommunications Station, Newport.
- Naval Computer and Telecommunications Station, Japan.
- Naval Computer and Telecommunications Station, Puget Sound.

They have LCM procurement authority for up to one million dollars. They will assist in BITS project execution and will manage and oversee local BITS activities (including APTS). In addition, they will provide technical assistance and training to APTS; review and approve all APTS actions for base communications requirements between $25,000 and $100,000; and will review and coordinate all APTS actions that require

NAVCOMTELCOM approval and ITAC procurement action. [Ref. 12:p. 6-7]

4. APTS

This is the local or base level for BITS acquisition and implementation. It is the requiring activity. The key personnel at this organizational level include the base CO, the contracting officer's technical representative (COTR), and mission subject matter experts. Local bases and stations have LCM procurement authority for up to $25,000. Primary functions at this level include: defining base requirements; obtaining necessary funding from major claimants; performing acquisition planning and LCM documentation; managing systems; and performing small purchases [Ref. 12:p. 6]. Chapter V describes the APTS role and functions in detail.

Figure 6 [Ref. 6] illustrates the Navy organizational structures and acquisition chain of command concerning base communications. NISMC and ITAC report to the Deputy Assistant Secretary of the Navy for C4I, Electronic Warfare, and Space Systems (DASN C4I/EW/Space) concerning procurement and acquisition matters. The Assistant Secretary of the Navy for Research, Development and Acquisition (ASN RD&A) oversees all Navy procurement programs.

D. BITS ACQUISITION IN PROGRESS

A Navy base communications specifications document has been developed by NAVCOMTELCOM to establish operating

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participate in an advisory role in addition to their normal project oversight role. NCTAMS LANT will assume the role of primary project manager. Participating in the USNA upgrade process will be representatives from NCTS San Diego and NCTS Pensacola, who will take lessons learned from the USNA implementation and export their knowledge to their respective geographic regions. [Ref. 17]

NAVCOMTELCOM will provide additional support with this USNA project. Headquarters personnel will assist in the development of LCM documentation, in determining base requirements, and in drafting key solicitation sections. Documentation developed during this BITS implementation project will be used as templates for subsequent acquisitions.

The following is a plan of action and milestones (POA&M) for the USNA BITS execution:

- Conduct government site survey . . . . . November 1991
- Forward procurement package to ITACEN . . December 1991
- Issue solicitation . . . . March 1992
- Award contract . . . . September 1992
- Begin implementation . . . . October 1992
- Begin Phase I testing . . . . November 1992
- Begin Phase II testing/receive test trunks . April 1993
- Cutover switch/begin Phase III testing . . . . May 1993
- Achieve final acceptance . . . . June 1993

2. Navy Weapons Station, Seal Beach, CA

The Seal Beach BITS implementation will be the second in the series of upgrades using the newly developed specifications. It is also the West Coast prototype.

Although USNA will serve as the test for the specifications and for the management process required for BITS implementation, any possible problems encountered which could delay its proposed final acceptance date will not affect the planned acceptance date for Seal Beach. [Ref. 18]

NAVCOMTELCOM will coordinate and clear all LCM and procurement documentation for this project. Naval Computer and Telecommunication Station (NCTS) San Diego will provide project management oversight and procurement assistance. Seal Beach personnel will perform the functions of the COTR. The following is an ambitious acquisition POA&M schedule for Seal Beach: [Ref. 19:p. 15-16].

- Conduct government site survey . . . . . January 1992
- Forward procurement package to ITAC . . . February 1992
- Issue solicitation . . . . April 1992
- Award contract . . . . September 1992
- Begin implementation . . . . October 1992
- Begin Phase I testing . . . . November 1992
- Begin Phase II testing . . . . April 1993
- Cutover switch/begin Phase III testing . . . May 1993
- Final acceptance . . . . June 1993

E. SUMMARY

The procurement of information systems in the Navy is subject to stringent regulations. NAVCOMTELCOM provides the PIP, an indepth implementation guide for personnel involved in

the acquisition of BITS. Utilizing this guide will help ensure compliance with higher DOD and Navy instructions. Additionally, the PIP delineates the responsibility of key players in the process. The PIP is a clear "how-to" manual for acquisition of BITS.

IV. ECONOMIC ANALYSIS OF BITS

A. HISTORICAL FUNDING STRATEGY

Prior to the divestiture of AT&T in 1984, most base communication assets were leased. It was accepted that such items as intra-base telephone lines and terminal equipment were provided on a lease from the telephone company. These telephone assets were generally operated as if they were a utility and managed by the public works department. Purchasing systems was not commonly practiced. Many bases continue to operate under outdated leases. [Ref. 20] To capitalize on the competitiveness that now exists in the telecommunications industry, a different approach should be taken. When it comes to providing telephone systems, the objective should be to achieve the most cost efficient method of doing business.

B. CURRENT FUNDING STRATEGY

Now that the telecommunications field is competitive, purchasing a system is a more available option than it had previously been. Decisions need to be made on the basis of what method of obtaining a system, lease or buy, is the most economically sound approach. Several studies have been undertaken within the DOD to determine which method of acquiring telephone systems is the least expensive. This

thesis summarizes two studies undertaken in the last few years that examine the issue of lease versus purchase for base communication systems: the Oakland Army Base Study and the Navy Leasing Feasibility Study.

1. Lease Versus Buy Decision Factors

The two studies considered cost factors alone. When an organization must decide whether to lease or purchase a system, there are generally more issues involved than just price. These issues could drive the decision on how a command wants to procure a telecommunications system.

a. Timeliness

One of the most attractive features of leasing is that it requires only a small outlay of funds over a period of time. While the overall expenditure of a lease over time may exceed that of an outright purchase, it is simpler for a Navy organization to fund these smaller payments. Large expenditures require a long lead time because they must be budgeted through the Planning, Programming and Budgeting System (PPBS) cycle, a more time consuming and administratively burdensome process. Using a simplified example, approval of a base communication system carrying a purchase price of $30,000 would require approval and planning by an Echelon III command. Leasing costs for that same system may amount to only $4,000 per year over a period of ten years. The smaller annual price of leasing requires approval on a

much lower level within the procurement process and is likely to be more expeditious. While it is evident that the purchase option is more economical compared to leasing ($30,000 versus $40,000 total) an organization that wants a system quickly and with minimal effort may prefer to lease it.

b. Management

When considering cost factors of leasing versus buying a system, some items are difficult to quantify. One notable area where this holds true is the management involved in setting up a new system. When a system is leased, some of the management functions associated with the system are accomplished by the lessor within the terms of a lease. The contractor overseeing the lease will manage many of the details involved with setting up a new system such as ensuring that equipment is available at the proper place when needed, and completing required documentation. Purchasing a system would involve more planning on the part of the organization involved and would therefore cost more in terms of manpower. Resources such as manpower are hard to come by, and this may add to the attractiveness of leasing.

c. Regulations

To counter short run thinking that may prejudice an organization into entering into a lease, SECNAVINST 5231.1 mandates that assets be purchased unless overriding cost savings can be proven in the case of leasing [Ref. 8:Encl. (3)

p. 2]. Both the Oakland Army Base Study and the Navy Leasing Feasibility Study prove that purchasing saves money over leasing. In effect, this forces bases to buy a system. Mandatory purchasing will limit the ability of many Navy bases to perform upgrades such as BITS because current budget projections show that funding for these projects will be extremely limited. This is detrimental because these bases will continue to pay relatively high rates for leasing outdated equipment until funding is obtained for purchasing a system. [Ref. 21:p. 1]

C. OAKLAND ARMY BASE STUDY

The Oakland Army Base Study, conducted in 1988, looked at procuring the same type of equipment as would be needed for BITS implementation. It succeeded in identifying applicable cost categories for each alternative. It evaluated recurring and non-recurring investment cost categories for both the purchase and lease alternatives. The non-recurring costs consisted of replacing the cable plant and procuring the telephone switch and associated equipment costs. Since the Oakland Army base did not have a sufficient number of personnel for operation and maintenance (O&M), both alternatives were analyzed with the understanding that contractors would provide that service on an ongoing basis.

A lease to purchase (LTOP) option was used instead of a straight rental to simplify matters. If a straight rental

agreement was entered into, it would mean equipment went back to the lessor at the end of the lease's term. To make a comparison with buying in that case, salvage value of the equipment would have to be calculated making the analysis more involved. When comparing LTOP to purchasing, there is no need to calculate salvage value of the purchased equipment. At the end of the study, both systems will be owned outright by the military organization.

Certain assumptions have been made in conducting this study [Ref. 22:p. 1]:

- The economic life for cable plant is 35 years.
- The economic life for an electronic switch is 20 years.
- The economic life for telephone instruments is 10 years.
- Under the lease alternative, the government will accept a 10 year lease to own contract for the new telephone system.
- The analysis encompasses a period of 20 years.

In depth calculations are available in the original document. A cost summary for the two alternatives follows. Clearly the purchase option provides cost savings over the lease option.

LEASE OPTION	PURCHASE OPTION
Non-recurring costs: cable plant replacement $935,206 general & administrative (G&A) expense $342,327 site prep $228,987 engineering/installation $543,983	Non-recurring costs: cable plant replacement $925,206 switch & equipment $2,901,493 G&A expense $1,415,879 site prep $228,998
TOTAL $2,040,503	TOTAL $5,471,576
Recurring costs: contractor O&M $325,998 switch lease $728,839	Recurring costs: contractor O&M $325,998
@20 years** TOTAL $15,992,857 **adjusted for inflation	@20 years** TOTAL $9,038,974
TOTAL PROJECT COST $18,033,360	TOTAL PROJECT COST $14,510,550

The cost savings shown are substantial, but there is a flaw in the way the analysis was carried out. Although inflation was accounted for, there is no present value determination. The model fails to consider the time value of money. Dollars that are not spent today can be used to invest in other projects and yield a return that would otherwise not be realized. This builds a bias toward purchasing. However, because there is such a substantial difference (over $3M and

more than 24% cost savings) the outcome of purchasing as a more economical option should not change even if present value discounting occurred.

D. NAVY LEASING FEASIBILITY STUDY

To obtain a more recent and relevant analysis of lease versus buy, NAVCOMTELCOM commissioned Booz, Allen & Hamilton Inc. to conduct a study in February, 1992. The stated purpose of this study was to:

> Perform a comparative analysis of fixed price lease and purchase pricing options for telecommunications switching systems...(and) provide a basis for further study of lease pricing at individual bases if the data and analysis indicate that the Navy could derive substantial benefit from leased pricing. [Ref. 21:p. 2]

The Navy Leasing Feasibility Study (NLFS) sought to provide the groundwork on the lease versus buy decision to fit into the BITS framework. BITS does not introduce much new equipment. Instead, it integrates present communication assets and provides the capability to incorporate future information systems into the BITS architecture. The primary costs involved in installing BITS are the switching equipment and communication lines needed to link assets together.

The NLFS obtained its cost information by soliciting information from several telecommunications vendors. A site profile of a typical Navy base was presented to each vendor who in turn provided pricing data. The following parameters were specified [Ref. 21:p. 6]:

- The scenario would encompass only the cost for equipment and its installation and not service.
- A baseline purchase price would be provided that the vendors could use to determine their lease price.
- Straight lease or rental would not be an option. LTOP would be used.
- The contract term would be 10 years.
- The vendor would not carry any risk of cancellation of the lease.
- Vendors participating in the study required that their identities remain confidential.

The dollar amounts in the NLFS were presented in both actual and present value terms. The Federal Information Resources Management Regulation (FIRMR) states that a discount rate of 10 percent should be used when performing an analysis of program alternative [Ref. 21:p. 17]. This is an artificially high rate considering the current fiscal market. Office of Management and Budget (OMB) Circular A-104 allows use of a discount rate tied to the current yield on government securities when conducting a lease versus purchase analysis of capital equipment with a life span of more than five years. Since this study meets that criteria, a rate of 7.55 percent was used.

Leasing terms were computed using both a fixed rate and a floating rate plan. Under the fixed rate plan, the contractor bears the risk if there are changes in the market rates. Because of these risks there is an additional premium that is included in this option that drives the cost up.

Results of the outcome of the study are summarized in the following table [Ref. 21:p. 20]. This study reinforces the Oakland Army Base Study showing that leasing is more expensive than purchasing. The cost savings involved with buying a system are significant, up to as much as 25.32%. These two studies justify the mandate in SECNAVINST 5231.1 to purchase systems and save precious defense dollars.

VENDOR A LEASE (Fixed Rate)	**VENDOR A LEASE** (Floating Rate)	**PURCHASE PROFILE**
Total Cost: $29,536,968 (actual dollars)	Total Cost: $28,221,396 (actual dollars)	Total Cost: $23,570,000 (actual dollars)
Total Cost: $20,903,832 (present value)	Total Cost: $19,980,450 (present value)	Total Cost: $18,931,508 (present value)
$ difference between lease versus purchase (actual dollars) $5,966,968 (present value)	$ difference between lease versus purchase (actual dollars) $4,651,396 (present value):	
$1,972,324	$1,048,942	
% difference between lease versus purchase (actual dollars) 25.32% (present value) 10.42%	% difference between lease versus purchase (actual dollars) 19.73% (present value) 5.54%	

E. SUMMARY

Bases implementing BITS will face the decision to lease or buy new equipment. They should also reexamine options on current systems. This decision will become more difficult in

times of limited dollars. In the long run, purchasing is more cost effective, but requires an up front lump sum expenditure. While it is more difficult to obtain funding for purchasing a system rather than leasing one, the bottom line is that cost savings usually result from outright purchase.

V. ACTIVITIES PROVIDING TELEPHONE SERVICE (APTS)

A. BACKGROUND AND ORGANIZATION

Activities Providing Telephone Service (APTS) currently manage telephone services at the base level. They operate and maintain as well as plan, design and implement the network technology for the base telephone system [Ref. 23]. As of this writing, APTS are not responsible for automated data processing equipment (ADP) or other data equipment. The infrastructure for any base telephone system is comprised of three primary components:

- The backbone cable plant.
- The base telephone switch or private branch exchange (PBX) which is either analog or digital.
- A universal wiring scheme.

Throughout the Navy and Marine Corps, there are 166 APTS with a variety of resource sponsors and under the direction of a variety of major claimants. As illustrated in Figure 7 [Ref. 24], of the 141 Navy APTS, only twelve fall under the NAVCOMTELCOM major claimancy. As of January 1992, two more APTS have been transferred to NAVCOMTELCOM responsibility from Commander-in-Chief Atlantic Fleet (CINCLANTFLT) and from the Naval Sea Systems Command (NAVSEASYSCOM).

Local commanders are responsible for telephone management procedures which, Navy-wide, creates an uneven dispersion of

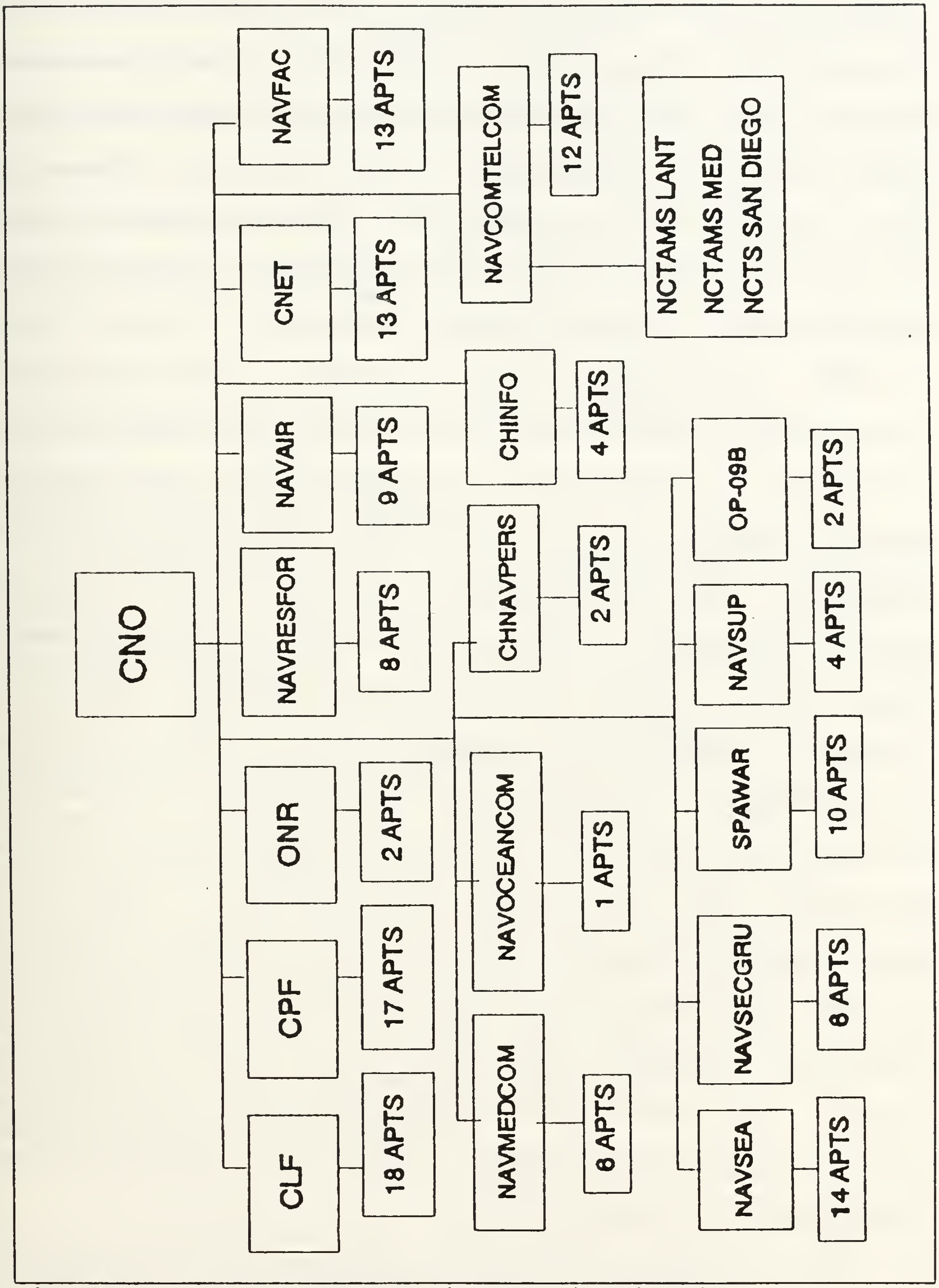

Figure 7. Current APTS Claimancy Distribution

quality and cost-effective telephone service. There is no standard APTS organization. Individually, each APTS must compete with other high-priority missions of the command for scarce resources and manpower. [Ref. 25:p. 5] Because of this, most APTS have struggled just to maintain current levels of daily operation. Long range planning is difficult to accomplish due to lack of stable funding.

New technologies have created new integrated communications systems which now makes base communications more vital in direct support of C4 operations. The advent of secure telephone units III (STU-IIIs) has accelerated this importance. Recognizing this new role for telephone systems and for the need of unified policies for systems management, the Director of Space and Electronic Warfare, OPNAV 094, tasked NAVCOMTELCOM with evaluating current APTS procedures and identifying a strategy for standardization. NAVCOMTELCOM proposed that its field activities assume APTS functions throughout the Navy shore establishment. This will effectively realign base communications responsibilities under a single major claimant and resource sponsor. With this APTS functional transfer, the Navy evolves closer towards the concept that communications will align under a NAVCOMTELCOM field activity that focuses on both inter- and intra-base communications [Ref. 26:p. 2].

NAVCOMTELCOM must tackle two major problems in conjunction with successful functional transfer. One involves the

standardization of the organizational structure of the APTS. The personnel mix at each APTS is diverse. Many are comprised only of government employees (DOD civilians and military personnel). Many have a mix of government workers and of contract personnel, and some utilize all contractors. The second obstacle is funding. Many APTS are supported by the Navy Industrial Fund (NIF). Other APTS are mission-funded. Standardization of funding will make acquiring new equipment and upgrading systems somewhat easier and less redundant.

B. APTS AND THE BITS CONCEPT

The functional transfer of all APTS to the NAVCOMTELCOM claimancy is a logical first step for the successful implementation of BITS. The primary components of a base telephone communications system are three of the seven components that comprise the BITS subarchitecture. (Refer to Chapter II, Section B.2). Consolidating all APTS under a single claimant command will ensure the standardization of telephone functions for all organizations involved and will establish a uniform upgrade of the outdated telephone systems as funding permits. The APTS will play a major role in building the fully integrated communications environment envisioned by the BITS concept.

A major step in BITS implementation will be to upgrade existing telephone systems. At the base level, APTS have the responsibility for executing such an upgrade project. As

managers of current base systems, they will be the key in initiating the acquisition of BITS requirements specific to individual commands. They will be directly responsible for evaluating and meeting base user needs. They must ensure that contracts awarded as part of the BITS implementation and system upgrade meet these user needs and that end user satisfaction is achieved. [Ref. 11:p. 6]

Specific upgrade and implementation responsibilities of the APTS [Ref. 11:p. 6-9] include:

- Define and express base requirements. This will be accomplished through site surveys with results documented in a site-specific Statement of Work (SOW). The Base Communications Specifications (BCS) will be the source used.

- Obtain necessary resources. This must include financial and personnel resources. APTS will be responsible for acquiring the funding for contracts necessary for the upgrade and implementation project.

- Prepare required documentation. This pertains to all life cycle management (LCM) documentation.

- Provide assistance in contract execution. This will encompass the entire contracting process from solicitation to contract awards. This will ensure the "technical integrity" [Ref. 11:p. 8] of the upgrade. APTS must also provide assistance when any technical changes develop.

- Systems management. This will involve acceptance and operation of the upgraded and/or procured system. APTS will be responsible for oversight testing and for determining any future growth requirements of the system.

The ultimate objective of the APTS functional transfer is to establish a "broad-based field organization" that "effectively establishes a primary activity at the base level" with the "responsibility for communications both on and off

base" [Ref. 27:p. 1]. This will be a major stride in establishing the communications ashore portion of Copernicus. Under the NAVCOMTELCOM claimancy, the merged APTS will become a department or division subordinate to such activities as Naval Computer and Telecommunications Area Master Stations (NCTAMS) or Naval Computer and Telecommunications Stations (NCTS). Ten of these activities will be designated as APTS Regional Coordinators. Figure 8 [Ref. 24] captures the one claimancy projection for APTS. The vision is for APTS to be comprised of all components of the BITS subarchitecture which will include all ADP and data related equipment required for a fully integrated voice and data system. The future objective is for APTS to become part of the Network Management Center, the focal point of the BITS concept.

C. THE APTS FUNCTIONAL TRANSFER

1. Purpose

To reiterate, the primary thrust for the transfer of all APTS to one claimancy is for the standardization of base telephone systems. The objective is modernization. Navy systems will be "upgraded or replaced with state-of-the-art systems" to provide "enhanced support to the Navy global mission." [Ref. 11:p. 3]. This transfer paves the way for BITS implementation and marks an establishment for the ashore portion of the Copernicus architecture. A secondary, long range goal of the transfer is to provide communications

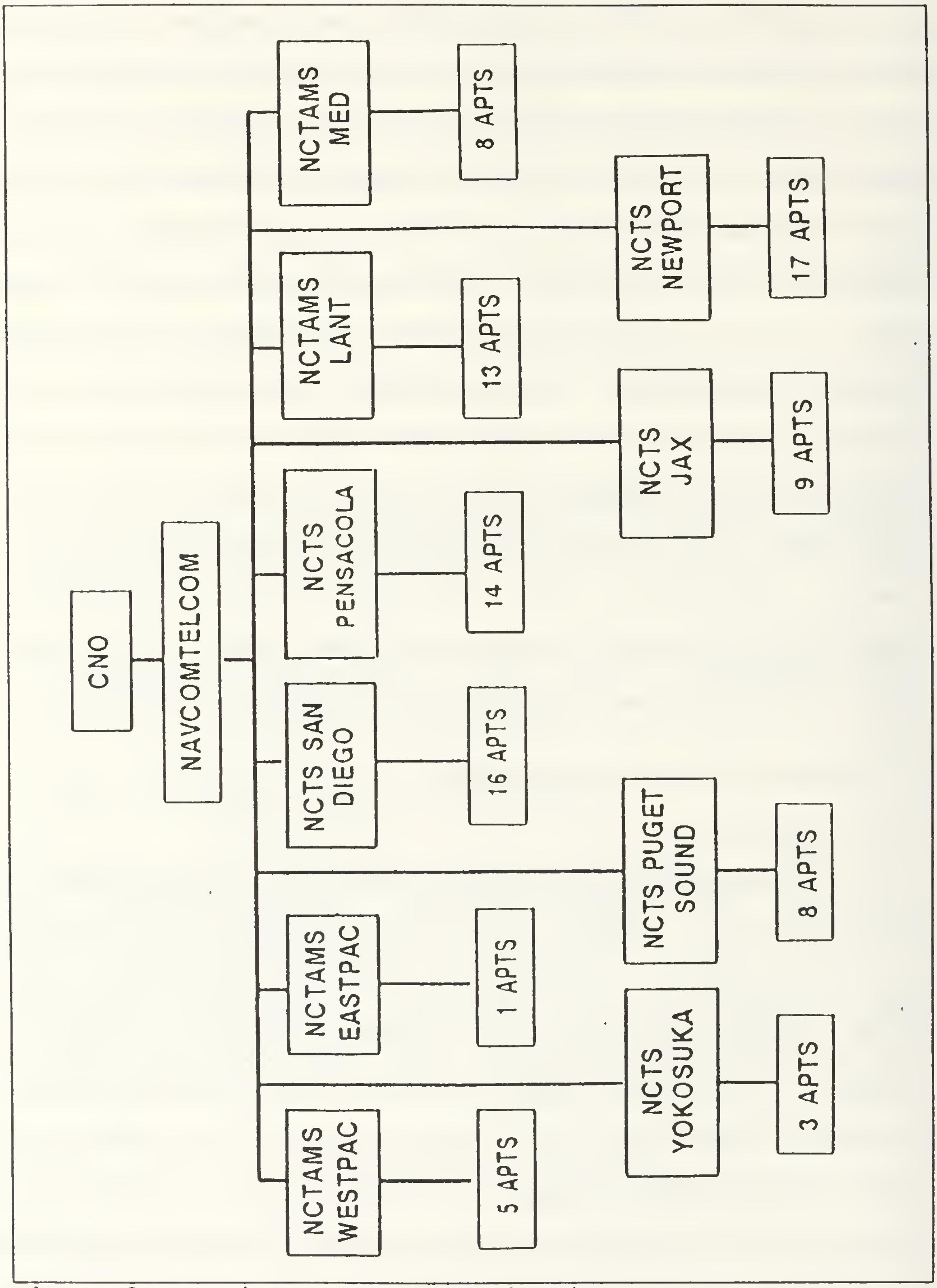

Figure 8. Projected APTS Distribution

services on a "fee for service basis on each base or installation." [Ref. 27:p. 2].

2. Strategy

BITS implementation and the APTS functional transfer will transpire concurrently. It is not imperative or necessary that one endeavor be completed for the achievement of the other. Both will converge with the establishment of the NMC.

A survey of all APTS was conducted by NAVCOMTELCOM and set the stage for development of a functional transfer strategy. APTS operations were diagnosed, and based on functions performed, volume of workload, and current organizational structure, a plan for their transfer emerged.

a. The Original Plan

Analytically, NAVCOMTELCOM reviewed several options as models for the revision and realignment of the APTS organization. From these options, a hybrid model developed comprised of the following six elements:

- Standardize APTS classes within emerging NAVCOMTELCOM organizations.
- Convert all APTS to Navy Industrial Funding.
- Phase the transition of non-NAVCOMTELCOM APTS into the NAVCOMTELCOM major claimancy.
- Integrate the APTS with the proposed Network Management Center (NMC) organization.
- Incorporate Open Systems Interconnection (OSI) standards.
- Centralize contract management.

In the hybrid model, three classes of APTS were proposed. Class I APTS were based upon functional responsibilities performed for a geographic region. These APTS, located in areas of concentrated naval activities, were to be renamed Consolidated Base Communications Offices (CBCOs). Class II APTS were to be within a NAVCOMTELCOM local organization on bases and stations within a CBCO region. Class III APTS, smaller versions of Class II APTS, were to be primarily made up of naval reserve, naval information and recruiting command region activities as well as Marine Corp APTS. They were to receive support from CBCOs but were not to be functionally transferred to the NAVCOMTELCOM claimancy. [Ref. 25:p. 14]

A three phase transition method was developed to accomplish the successful transfer of APTS not currently under the NAVCOMTELCOM claimancy. In Phase I, CBCOs and APTS within major claimants that are largely funded by NIF were to be transferred. In Phase II, the majority of mission-funded APTS, primarily in the Fleet Commander-in-Chief claimancies, were to be transferred. Phase III transfers were to encompass all remaining APTS.

b. The Current Plan

The present plan for the APTS functional transfer is not much different from the original strategy. The elements of the hybrid model will still be actively pursued.

However, APTS will not specifically be designated as Class I, II or III. But the basic premise for categorization as outlined in the preceding section will remain. Transfers will not necessarily occur in the phases described. [Ref. 28] Also, converting mission-funded APTS to NIF is under evaluation and review by Navy Comptroller (NAVCOMPT).

Ten Echelon III commands will be designated as Regional Coordinators within the NAVCOMTELCOM claimancy. They will perform APTS functional transfer responsibilities. Figure 7 shows three Echelon III commands, NCTAMS LANT, NCTAMS MED, and NCTS San Diego who currently provide technical and management support to all Navy and Marine Corps APTS. This once was the function of Telephone Management Detachments (TMDs). The first step of the current APTS functional transfer plan is to designate seven more Regional Coordinators to provide such support. Figure 8 delineates these ten projected Regional Coordinators.

Regional Coordinators will also serve as "local base communications managers for all Navy activities in their immediate vicinity." [Ref. 27:Encl (1) p. 1]. They will be responsible for executing all functional transfers for APTS within their geographic region and for consolidating APTS responsibilities wherever possible. For APTS outside the immediate geographic vicinity of a Regional Coordinator, the Echelon III command nearest that APTS will prepare the functional transfer plan. When all transfers and transitions

are completed, the term "APTS" will no longer be used. [Ref. 27:p. 1]

NAVCOMTELCOM tasks NCTAMS LANT, NCTAMS MED, and NCTS San Diego with providing assistance to other Regional Coordinators in preparing functional transfer plans. Such assistance also includes: billing procedures, contractual authority issues, and assessing current equipment conditions. [Ref. 27:Encl. (1) p. 1] These Echelon III commands will submit completed functional transfer plans to NAVCOMTELCOM for review and modification. NAVCOMTELCOM will forward the transfer plans to the current major claimant of the APTS for input. With signature approval of both the current and the gaining major claimant, NAVCOMTELCOM will forward the functional transfer plan to NAVCOMPT and the CNO for "resource transfers and organizational administrative changes." [Ref. 27:p. 2]. Figure 9 [Ref. 27] delineates these basic steps for the current APTS functional transfer plan.

3. Management Impact

a. Regional Coordinators

The geographic regions designated for the ten projected Regional Coordinators delineated in Figure 8 will be determined by naval activity concentration. Figure 10 and Figure 11 [Ref. 27:Encl. (1) p. 4-5] illustrate the geographic dispersion of these Regional Coordinators worldwide.

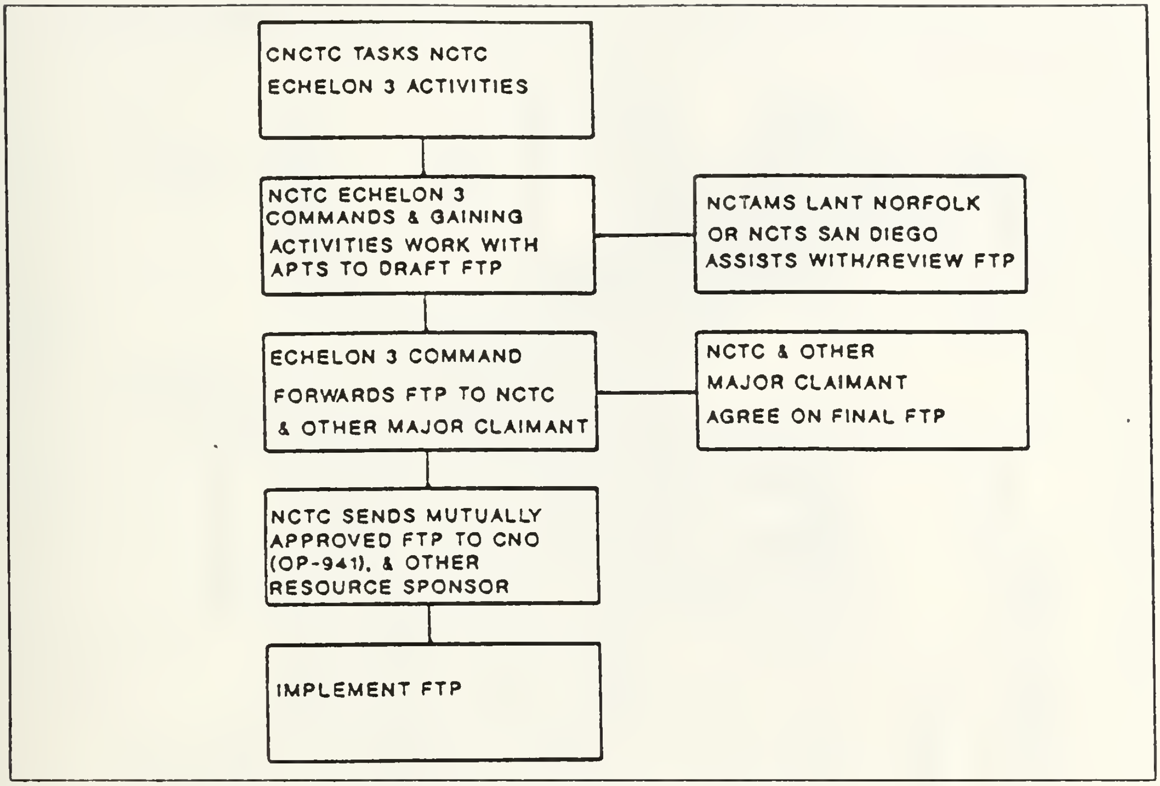

Figure 9. APTS Functional Transfer Plan

Each Regional Coordinator will be the center focus within its assigned area for technical and operational management of BITS implementation as well as telephone systems modernization. Planning and support for all integrated communications systems that fall within its realm are also primary functions. As depicted in Figure 12 [Ref. 27:Encl. (2) p. 3], the proposed organizational structure of a Regional Coordinator will include a division director who manages six function specific branches: services, area operations, system management, technical, operator service and management information systems. This division director will be assisted by a facilities manager and a financial manager. Regional

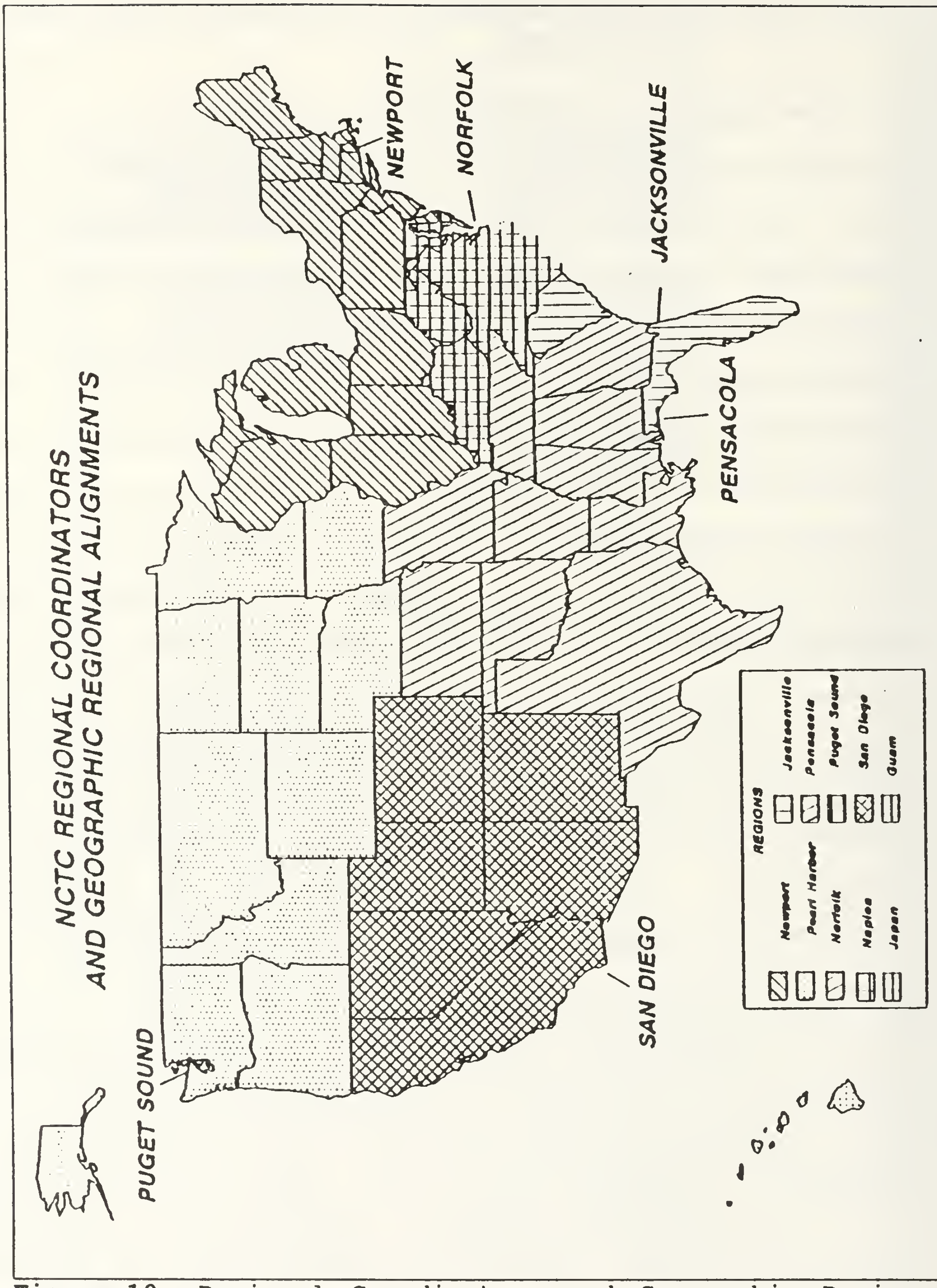

Figure 10. Regional Coordinators and Geographic Regional Alignments (US)

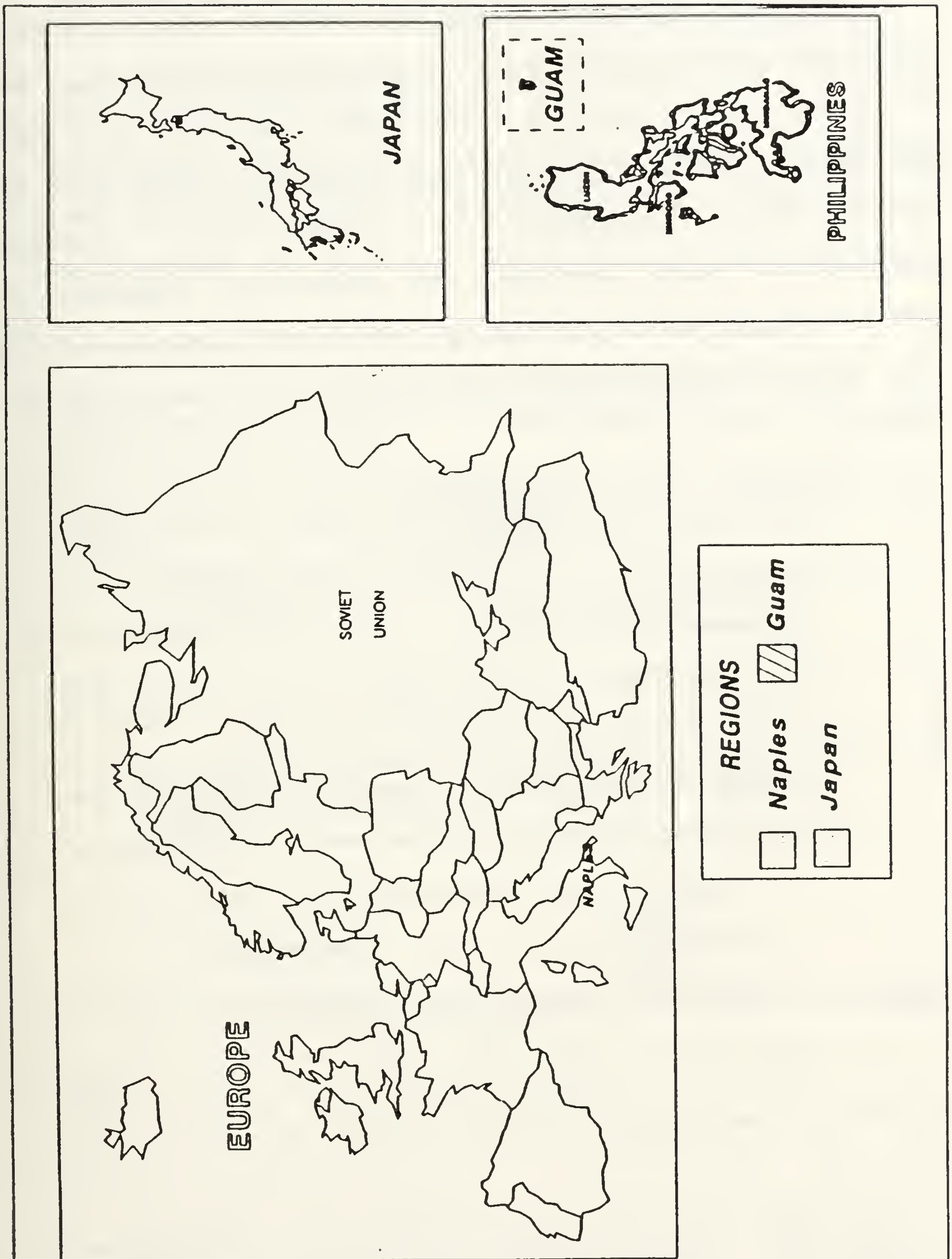

Figure 11. Regional Coordinators and Geographic Regional Alignments

Coordinators will provide policy and guidance relating to base communications in the areas of operations, maintenance, and management. In the area of acquisition, they provide project management, life cycle management, technical consulting and implementation management. Fundamentally, Regional Coordinators must provide the technical support and operational direction needed to ensure the highest quality base communications services within its area. [Ref. 27:Encl. (2) p. 1]

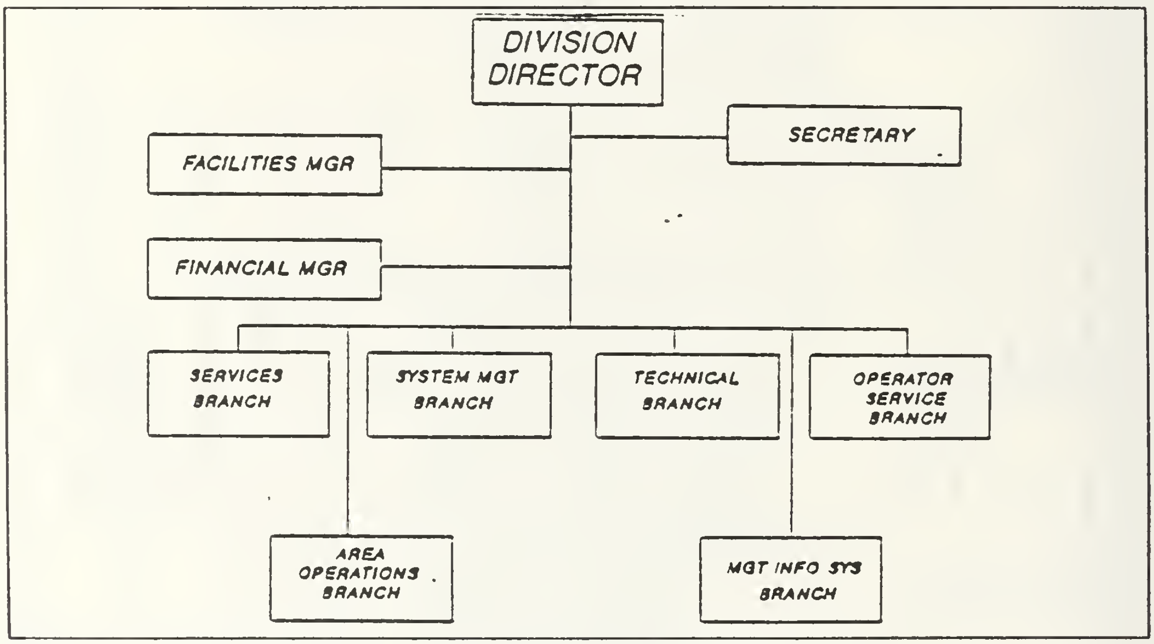

Figure 12. Regional Coordinator Organization

Specific responsibilities of the Regional Coordinators include, but are not limited to: [Ref. 27:Encl. (2) p. 2].

- Performing long range budgetary, administrative, personnel, logistic, security, and resource management functions.

- Preparing and negotiating regulated communications service funding and support agreements with DOD components.

- Periodically reviewing local level procedures to ensure compliance with regulations.

- Implementing procurement procedures within procurement authority and reviewing requests for equipment and services which exceed delegated procurement authority.

- Maintaining and updating base profiles within assigned region.

- Implementing Quality Assurance Review programs.

- Maintaining a liaison with contractors, local base communications providers and NAVCOMTELCOM concerning base communications issues.

- Evaluating contractor proposals for technical and administrative changes to established contracts.

- Coordinating complex trouble calls with contractors.

- Reviewing major military construction projects.

- Providing training assistance as required to local base communications providers.

- Maintaining a Telecommunications Summary (TELSUM) database and forwarding a report to NAVCOMTELCOM monthly.

- Validating Telecommunication Service Requests (TSRs).

b. Local Base Communications Providers

Formally APTS, the day-to-day management of all communications functions and responsibilities at the base level will center around the Local Base Communications Provider. Such management includes the administration, operations, maintenance and support for all base communications facilities as well as the communications requirements of all ships berthed at the pier. As Figure 13

[Ref. 27:Encl. (3) p.3] illustrates, the proposed organizational structure for the local base communications providers will include a division director and three function specific branches: services, operations and maintenance. Primarily, the Local Base Communications Provider will function as the liaison between the user or customer and the services or equipment contractors. Other provisions within the realm of the Local Base Communications Provider include information systems directory services, facilities planning, required operator services, AUTOVON, moves and changes, installation, and disconnections. These providers will play a vital role in the implementation of BITS.

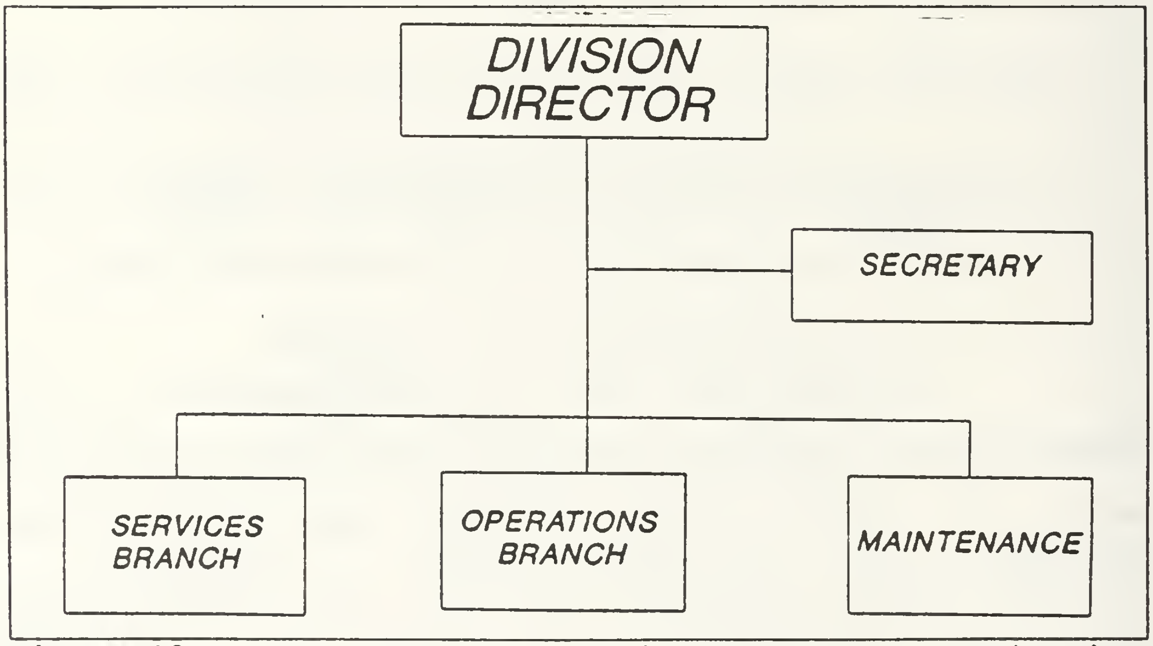

Figure 13. Local Base Communications Function Organization

Specific responsibilities of the Local Base Communications Providers include, but are not limited to: [Ref 27:Encl. (3) p. 1].

- Maintaining a complete and current inventory of all equipment and services currently under contract.

- Working closely with Regional Coordinators concerning technical assistance.

- Developing cost efficient alternatives to satisfy communications requirements.

- Planning for any new and additional services required.

- Working closely with customers concerning current and future communications services and requirements.

- Providing liaison between users and contractors.

- Submitting TSRs to Regional Coordinators.

- Providing communications billing for customer activities.

- Ordering communications services, equipment, and moves and changes for the specific base or activity.

- Reviewing requests for local equipment and services.

- Providing TELSUM data to Regional Coordinator.

- Updating information systems directory.

- Providing telephone operator services.

- Conducting Quality Assurance oversight.

- Administrating on-site cable requirements.

- Maintaining and following up on trouble reports concerning leased or government-owned services and facilities.

- Providing local management of the DSN, DDN, DCTN, FTS-2000, and AUTOVON services.

c. *Manning Requirements*

Currently, manpower at APTS includes a diverse mix of personnel including military, civilians, and contractors. The site surveys conducted by NAVCOMTELCOM for the planning of the APTS functional transfer strategy provided incomplete data

to adequately analyze manpower standards for reorganization once the transfer is complete. However, an Efficiency Review (ER) conducted by the Navy Regional Data Automation Center (NARDAC) Jacksonville enabled their personnel to successfully determine an optimum organization structure in transferring functions. Such an ER conducted at each of the projected Regional Coordinators may determine their manning requirements.

4. Budgetary Impact

In a financial summary brief compiled by NAVCOMTELCOM, anticipated operating costs after the APTS transfer will be: [Ref. 29:p. 3]

- Monthly total: $18M (O&M,N)
- Annual total: $218M (O&M,N)

In addition, upgrade costs and new systems procurement are estimated as $100 M (OPN) yearly for base cable and switch modernization. Expected savings after the APTS transfer will be based on management initiatives (such as blocking directory services from telephone lines) and consolidation. A conservative savings estimate of 15% (not across the board) is anticipated after the first year of the transfer with an $11M cumulative savings predicted by 1997. [Ref. 29:p. 3], [Ref. 30:p. 1] and [Ref. 28]

Prior to the 1984 divesture of AT&T, the APTS essentially ordered telephone service and paid the bill.

Switches, equipment, and cable were usually owned by the lessor [Ref. 25:p. 6]. The functional transfer of APTS, which involves nearly every resource sponsor and major claimant, will incur extremely complex funding considerations. Currently 28 APTS are supported by NIF. The remaining 136 are mission funded.

NAVCOMTELCOM developed a Telephone Modernization Plan (TMP) for upgrading base telephone systems Navy-wide. The TMP requirements were integrated into the Base Communications Assessment (BCA) for submission of Program Objectives Memorandum (POM) 90. Many individual resource sponsors did not fund the upgrades in their Sponsor Program Proposals. Without modernization, many APTS struggled or were unable to maintain adequate levels of service. Standardized funding for APTS, and hence, base communications, is necessary. Transfer of APTS to one claimancy is one step toward such standardization.

NAVCOMTELCOM looks toward the NIF as one solution for APTS and base communications funding standardization. Basically, NIF will set base communications fees and charges with an identical billing system for all users. Categories of service will be the same at all facilities. (Costs will be different due to external factors such as power requirements and rates.) [Ref. 28] The NIF provides a good method for funding a consolidated structure. This funding includes provisions for capital investments of hardware such as switch

procurement, minor construction projects, and management systems development [Ref. 25:p. 14]. Funding switch procurement through the use of a revolving fund and then paying back through stabilized rates over several years is easier to justify during the Planning, Programming and Budgeting System (PPBS) process [Ref. 25:p. 8].

There is an existing Commander, Navy Data Automation Command (COMNAVDAC) NIF Charter for NARDACs and specific Navy Data Automation Facilities (NAVDAFs) [Ref. 23]. COMNAVDAC's merger with NAVCOMTELCOM allows this NIF Charter to remain valid, but it must remain separate from mission-funded activities. The charter covers provisions for operating ADP equipment and providing support services for such equipment. Federal Information Resources Management Regulation (FIRMR) Amendment 19 redefines ADP equipment as Federal Information Processing (FIP) equipment [Ref. 31]. FIP equipment is defined as:

> Any equipment or interconnected systems or subsystems or equipment that is used in the automatic acquisition, storage manipulation, management, movement, control, display, switching, interchange, transmission, or reception, of data or information--[Ref. 31].

FIP equipment includes:

> Telecommunications networks and related equipment, such as voice communications networks; data communications networks; local area networks; terminals; modems; data encryption devices; fiber optics and other communications networks; packet switching equipment; terrestrial carrier equipment (e.g., multiplexers and concentrators); lightwave, microwave or satellite transmission and receiving equipment; telephonic (including cellular) equipment; and facsimile equipment. [Ref. 31]

NAVCOMTELCOM believes that providing base communications services is a logical function under the existing NIF Charter and recommends that APTS not currently under the NAVCOMTELCOM claimancy and operating as NIF activities be functionally transferred [Ref. 23]. The ideal objective is to convert to NIF all mission-funded or non-NIF APTS. This recommendation is still open to evaluation and review by upper echelon commands including NAVCOMPT. Currently, no conversions will be made unless the recommendation is approved.

If NIF funding is eventually approved for all APTS, those already utilizing NIF will provide the example for conversion to such funding procedures. This conversion from non-NIF activities to NIF will take at least two years based on the current budget cycle [Ref. 25:p. 16]. Therefore, mission funding will remain as the current method for non-NIF APTS in the interim.

With all APTS realigned under one major claimant, NAVCOMTELCOM will also be able to centralize contract management. This will enable many small requirements to be consolidated under one single contract. Such action can lead to more efficient procurement in terms of cheaper unit cost and government effort. With the flexibility of selecting the best options without individual contract delays and with procurements sized for maximized competition and therefore lower costs, centralized contract management will result in

overall savings on hardware procurement and maintenance contracts. [Ref. 25:p. 17]

D. SUMMARY

The evolution of APTS from mere managers of telephone equipment to eventual designation as Local Base Communications Providers is direct evidence of the vital role they will play in the successful implementation of the BITS concept. With subsequent assimilation into the Network Management Center, these activities will be the cornerstone to complete interconnectivity between all communications services offered at any one base. The first and concurrent step toward this realization is the standardization of all APTS under one major claimant. Successful functional transfer will involve complex issues that must be resolved and will take many years for completion. But it is a step in the right direction.

VI. ISSUES, CONCERNS AND CONCLUSIONS

After much research and examination, the authors of this thesis have formulated opinions of the BITS concept and its implementation. Those ideas are presented in this chapter.

Technological innovations in the field of telecommunications such as video teleconferencing, electronic mail, data base management, and automatic file transfers have propelled computer and communications services into an arena of prominence, importance and necessity. The demand for such services seems to outdistance the technical capability currently available on most bases.

With the proliferation of computer and communication systems that offer these services, developers and users are discovering the need for system components to communicate with one another or "speak the same language." [Ref. 32:p. 434].

> When work is done that involves more than one computer, additional elements must be added to the system: the hardware and software to support the communication between or among the systems. Communications hardware is reasonably standard and generally presents few problems. However, when communication is desired among heterogeneous (different vendors, different models of same vendor) machines, the software development effort can be a nightmare. Different vendors use different data formats and data exchange conventions. Even within one vendor's product line, different model computers may communicate in unique ways. As the use of computer communications and computer networking proliferates, a one-at-a-time special-purpose approach to communications software development is too costly to be acceptable. The only alternative is for computer vendors to adopt and implement a common set of conventions. [Ref. 32:p. 446]

Integration of computer and communications systems grows increasingly popular and practical. Worldwide, the OSI model is becoming the accepted architecture for standardization of protocols for such systems. With the evolution and acceptance of ISDN, voice and data integration will become globally possible.

A. THE BITS SUBARCHITECTURE

As discussed in Chapter II, the BITS subarchitecture incorporates the philosophies of both the OSI model and ISDN. BITS is a good concept. The following arguments and advantages explain why:

- An integrated network will allow users to access or request a variety of services through only one system.
- An integrated system will be easier to operate and maintain than will a variety of independent systems.
- Such a system can develop from existing communications resources and equipments.
- Several activities can pool common resources (money, manpower) when necessary to acquire and implement new hardware, software, etc. to support the integrated system (i.e., installation of fiber optic cable).
- There will only be one central management focus; one person in charge.
- The administration and management of one integrated system vice a variety of independent systems will be much simpler.
- Standardization and integration may be the best solution to a shrinking budget and shrinking manpower.
- Standardization of system protocols is the way of the future.

With every new concept there are always some viable concerns. The following are mentioned for consideration by base COs or other action officers responsible for BITS implementation. Although not resolved within the realm of this thesis, some of these elements may be possible future research topics. In any case, it is the opinion of the authors that these issues are not insurmountable and should not deter the BITS implementation process.

- Security. How is security managed and maintained on one integrated system that involves a variety of services each possibly requiring unique security needs?
- All activities involved with the base integrated system will have to agree and adhere to the standardization. Specific ways of thinking may have to change where the priorities and importance of the integrated communications system are concerned. Agreement as to the use of common resources will be directly involved.
- Legality and regulations. What are the requirements and regulations involved with integrating systems that provide administrative information to those systems concerned with tactical, operational and classified information?
- Certain activities may have to sacrifice authority over unique systems when integrated with a common system.
- Certain activities may not be willing to "give up" sacred resources to the "common pool."

Chapter II also explored the concept of the Network Management Center. As stated, the NMC will be the focal point for the administration and operation of all base communications. Once BITS is implemented at any one base, the continued success of its operation will depend primarily on how smoothly the NMC performs all functions.

Proper evaluation of manning requirements for such a vital organization is extremely important. The NMC may provide valuable leadership billets for naval officers with the 1100 designator. Manning requirements such as ranks, ratings, number of personnel and titles of each should be determined by a staffing standard. Such a study goes beyond the scope of this thesis but is brought forth at this time as a recommendation for a future research topic.

B. BRIEF EVALUATION OF BITS ACQUISITION

Chapter III explored the BITS acquisition process. This thesis briefly evaluates the strengths and positive aspects of that process and the acquisition strategy for BITS implementation. It also mentions some concerns and recommendations for possible further study.

1. The Strengths

NAVCOMTELCOM's acquisition strategy for BITS is well defined with roles and responsibilities of the key players explicitly identified in writing. This will help alleviate any potential duplication of effort, and when any problems arise, it will be clear where to seek assistance. The entire strategy is clearly outlined. Once a specific base is identified for BITS implementation, a plan of action and milestones is drawn up and a schedule is published for all involved. There is little ambiguity involved in the process.

Also, selecting two sites as prototypes for

implementation is a good approach. These sites will be closely monitored to uncover where problems in the acquisition process may exist. Final completion for both sites is expected to be attained in mid 1993. By uncovering problems at these sites in the early stages of implementation, costly mistakes should be avoided when BITS is put in place on a large scale.

There will be a good deal of uniformity throughout the BITS acquisition process. The use of COTS during procurement will be cost effective. Costs will be easier to predict and it will reduce the waiting time for implementation. Before the BITS program was fielded, well defined standards and specifications were developed with inputs from suppliers.

When a base assesses its needs, there are a variety of templates and CLINs to be used as guidelines. This makes the procurement much simpler for the contracting officer. Because the contracting officer will see requests for items in a standardized way, it will preclude him from misinterpreting what is desired and will allow for economies of scale. With several bases requesting the same item, a larger scale purchase should be less costly.

2. Some Concerns and Suggestions

Although procurement using COTS is planned, there is still a question as to whether suppliers will maintain the BITS system, or if Navy personnel will be trained to conduct

the maintenance themselves. Since both hardware and software are involved, it would appear that some maintenance and logistics support for spare parts, equipment repair and software upgrades will be required from external organizations. How that is going to be accomplished, and at what level, should be identified as soon as possible.

It is not too early to address systems maintenance. If BITS maintenance is the responsibility of the individual CO, users at USNA and Seal Beach should identify the type of maintenance they are looking for, evaluate the options provided to them by the suppliers (as either satisfactory or unsatisfactory), and discuss which option to select so that what is finally agreed upon is an acceptable arrangement for all concerned. This information should be provided to NAVCOMTELCOM and be forwarded to commands with subsequent BITS implementation scheduled.

A source of central Navy funding to support BITS implementation should be considered. With a central funding source managed by NAVCOMTELCOM, or a single delegated authority, the project as a whole might withstand financial pressure better than smaller separate ones. Should DON financial cutbacks increase in the future and seriously impact base planning budgets, any spending reductions could be shared among all participating bases instead of each individual CO being left to decide which of his/her projects (many among which BITS is the only one) would undergo budget cuts. A

central funding source could ensure continuation of BITS progress and ultimate realization.

Coordination among key players is an absolute necessity for successful BITS acquisition and implementation. Regular meetings among participating members should be held to ensure that the entire process is going smoothly. Lessons learned with recommendations should be developed and forwarded via Echelon III commands to NAVCOMTELCOM. Such information should them be disseminated by NAVCOMTELCOM to commands scheduled for future BITS implementation. Such coordination must be recognized at all levels so that questions can be quickly answered and any problems expeditiously resolved. Only through close coordination and cooperation throughout every phase of each implementation can BITS be brought to successful fruition.

C. LEASE VERSUS BUY

Purchasing telecommunication switches and lines appears to be the least costly method. The NLFS is a generic study which supports the purchase option and which can be applied to most naval bases. If an individual base CO believes unique circumstances exist on his/her base that would result in leasing as a more economical option, he/she can conduct a site specific lease versus buy analysis. A lease, however, can only be entered into if it shows cost savings over purchasing a system.

One area of concern is that while purchasing is less costly, it requires obtaining lump sum funding. With defense dollars so limited, this could lead to some bases being unable to upgrade existing systems. The result could be delayed or canceled system upgrades and BITS implementation.

D. APTS FUNCTIONAL TRANSFER

Chapter V described the current responsibilities of APTS and their link with the BITS concept and future implementation. Eventually, APTS will be renamed Local Base Communications Providers and their responsibilities will extend beyond those of merely providing quality telephone service to bases and stations. With the future objective of assimilation with the NMC, the ultimate integration of voice, data, and all communications services (the BITS concept) will be achieved.

In reality, since the NMC is only in the conceptual stage at this time, and since APTS are fully functioning, on-line activities, the logical place to begin BITS implementation at the base level is with the APTS. The telephone system will still be a major factor in base communications services, so upgrade and modernization is vital. Functional transfer of all APTS to one major claimant will enable consolidation of all resources necessary to expedite this upgrade.

This thesis explored the value and possibility of NIF funding for all APTS. As stated, at this time NAVCOMPT is

reviewing and evaluating such a proposal. Regardless of the type of funding decided for support of the APTS, standardization of funding is essential to eliminate redundancy and simplify administration.

As discussed in Chapter V, current manpower for APTS is a hodgepodge of civilian, military, and contract personnel. Standardization of manning requirements should be a benefit of having all APTS under one claimancy. As with the NMCs, a thorough evaluation of such requirements and the creation of a staffing standard will determine the best mix of manpower for the successful operation of the APTS. Again, such an analysis goes beyond the scope of this thesis but is recommended for future research.

E. OTHER COMMENTS AND OBSERVATIONS

Besides BITS, this thesis has described several other Navy architectures and subarchitectures created for the standardization and modernization of naval communications. Although born with good intentions, such a variety of similar architectures and coinciding objectives tends to cause some confusion. Created to reduce overlapping missions and redundancy among communications systems, they are inclined to be somewhat repetitious themselves.

These architectures and subarchitectures are currently under review at the OPNAV and SECNAV level. Eventual consolidation of some or all of these architectures will

probably take place. Copernicus may become the leading architecture, with BITS, representing ashore communications, as an integral part. The Naval Communications Control Architecture (NCCA) may be eliminated. Such consolidation is probably necessary to strengthen the architectural concept and to emphasize the importance of naval communications standardization. However, there is one concern. Copernicus concentrates on naval tactical communications and operations. As shown in the thesis, BITS provides a critical link in this scenario. But BITS is also concerned with the standardization of communications systems that provide administrative and logistic support as well as tactical support. Hopefully, this concept of integrating all such systems will not be lost if major architectures are not accepted or approved.

Finally, Figures 14 and 15 [Ref. 6] illustrate current systems, targeted and fully-funded, for the Air Force and the Army. Each is strikingly similar to the Navy's BITS subarchitecture. Perhaps it would be forward thinking to step beyond eliminating the redundancies of communications systems within the individual services and to look toward integration, interoperability and interconnectivity of communications systems for all the Armed Forces. In these times of deep budget and personnel cuts, any way of consolidating similar systems is an absolute necessity and may be the only way certain systems, architectures, and concepts can survive.

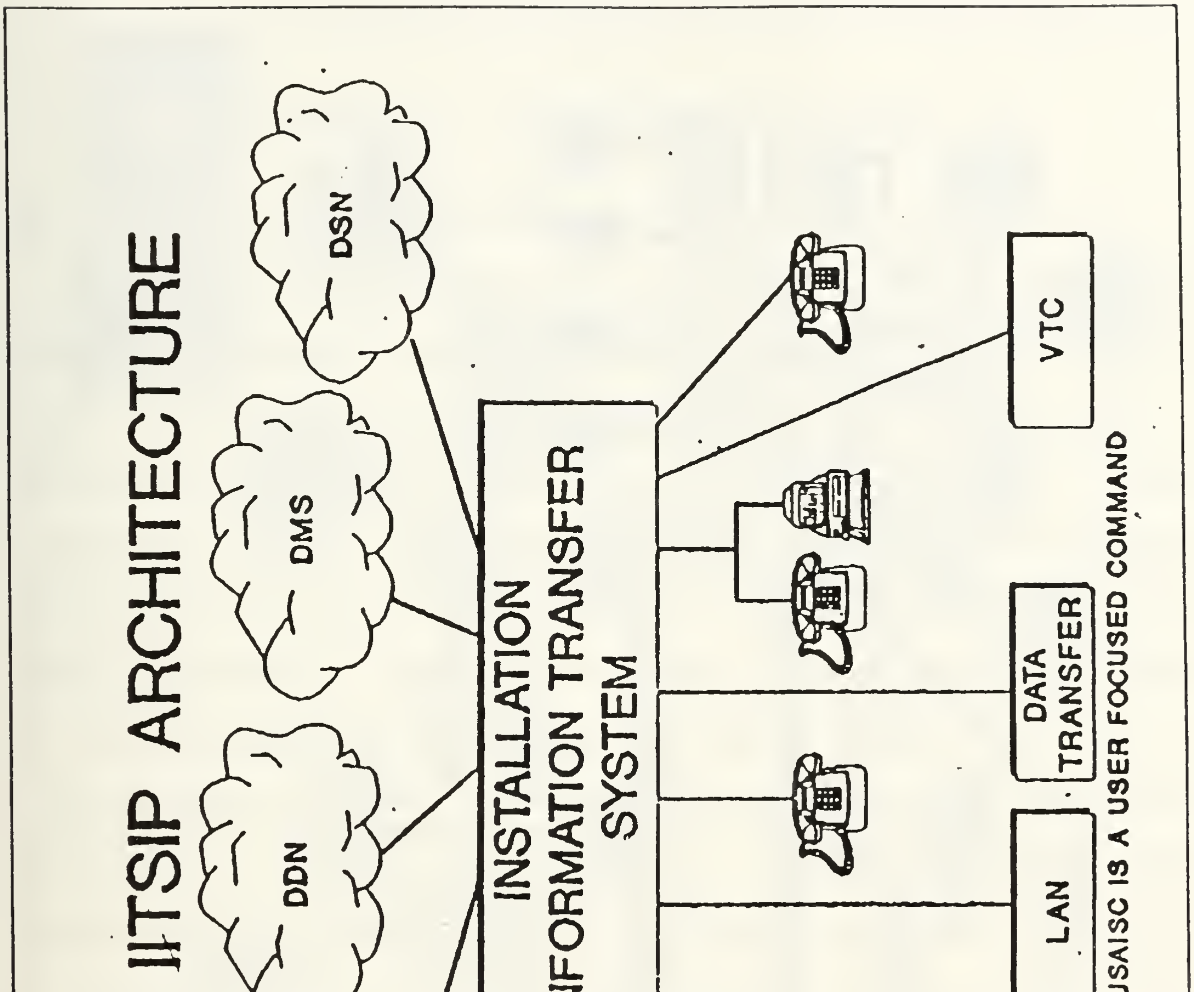

Figure 14. Army Architecture

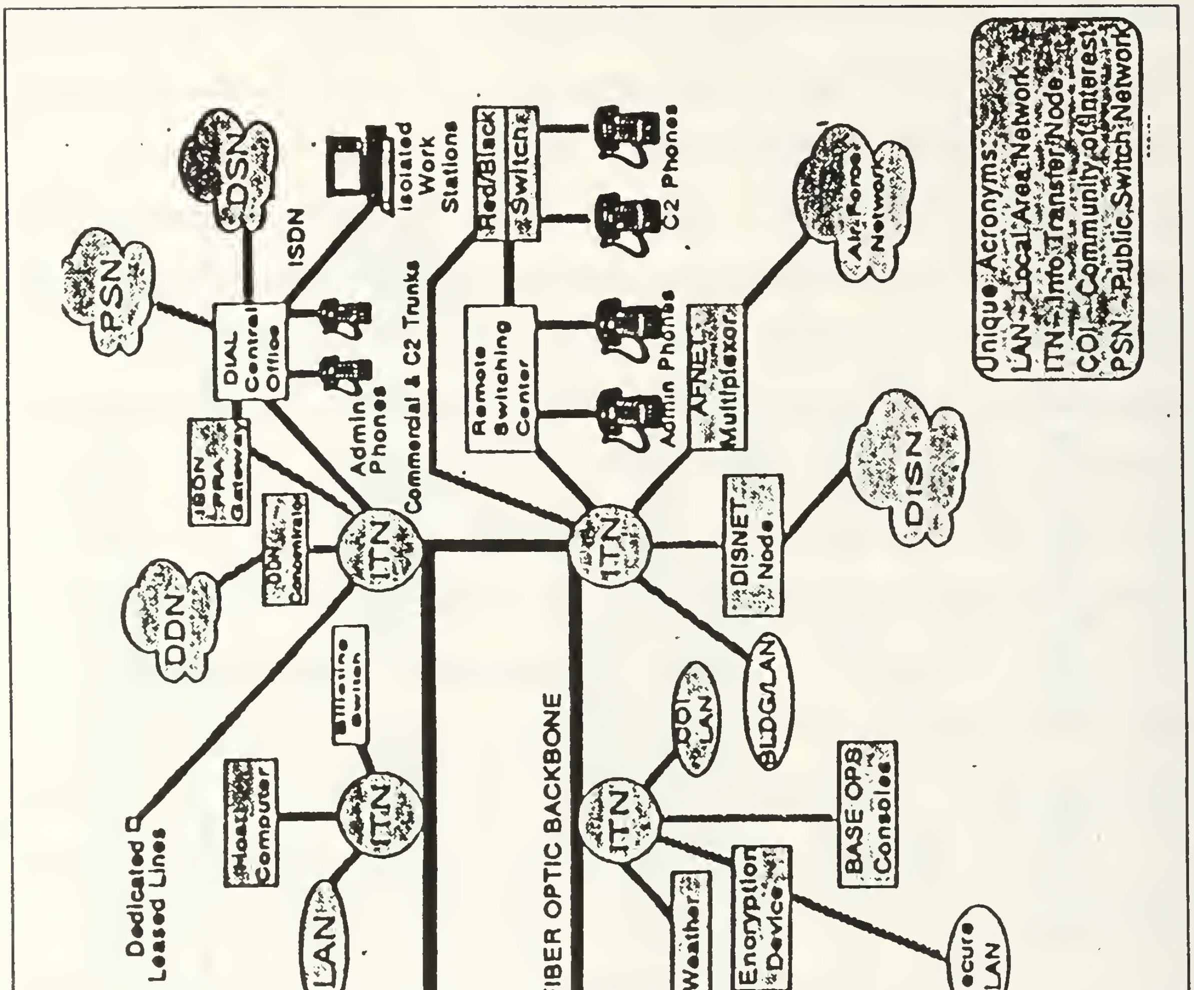

Figure 15. Air Force Architecture

APPENDIX A. FIBER OPTICS FOR BITS

A. INTRODUCTION TO FIBER OPTICS

Developments and demands in electrical communications, creating the need to transmit enormous amounts of information, have increased so rapidly in recent years that electromagnetic carrier waves of much higher frequencies are necessary. The "invention of the laser in 1960 made available a coherent light source some 10,000 to 100,000 times higher in frequency than the existing microwave generators." Outstanding advances in fiber optics since the early 1970s, particularly in a considerable increase in the life of a semiconductor laser and production of low loss fibers, has established the practicality of optical fiber communications. [Ref. 33:p. 2]

The advantages of fiber optic communications over other forms (such as other wire communications or radio frequency communications) are numerous. The large bandwidth (1 and 100 gigahertz (GHz)), respectively, for multimode and single-mode fibers over 1 km) provides the capability of carrying very high information rates. [Ref. 33:p. 11] Very low losses permit short distance communications with no repeaters and long haul communications with wide repeater spacing. The small size, low weight, ruggedness, and flexibility of optical fibers make them extremely ideal for military applications.

Such characteristics also provide benefits in storage, transportation, handling, installation and underground cable space. Natural electrical insulators, optical fibers can be incorporated into cables of non-conducting components which makes them immune to arcing or sparking and ideally suited for use in hazardous environments. With optical fibers there is no electromagnetic interference, small crosstalk, high security, and high resistance to chemical attack and temperature variations. [Ref. 34:p. 286]

As stated, optical fiber communications provides a tremendous advantage in military use. There are many other potential military application advantages such as high reliability and survivability in the most severe situations. The special features of fiber optics can have an impact on the military in two ways:

- Where a particular job is currently being done by conventional techniques but where fibers could do it better [Ref. 34:p. 292].
- Where fibers open up the possibility of achieving functions which are impracticable using conventional approaches [Ref. 34:p. 292].

Advantages of fiber optics can be ideally applied to such military uses as in short distance systems, mobile units, deployable links, long distance communications, and intermediate distance fixed links. The concept of BITS focuses on this last application. Intermediate distance fixed links typically range from 100 meters to many kilometers and

include headquarters complexes, bases, airfields, and shipyards.

> Bandwidth requirements range from very moderate, e.g. below 2 megabits per second where only speech communication is involved, to many tens and even hundreds of megabits for video, radar data, and sophisticated sensor outputs. The larger distance, higher bandwidth links in particular make heavy demands on the technology, especially since a high degree of ruggedness and all-around 'survivability' (e.g. ability to continue operating after nuclear irradiation and structural damage to portions of the complex) are required [Ref. 34:p. 293].

This Appendix studies the applicability of a fiber optic system as part of the implementation of BITS at any average-sized base.

B. DESIGN PROCEDURES AND SPECIFICATIONS

Figure 16 [Ref. 3:p. C-44]is an illustration of a generic BITS system. It is a closed loop bus topology with nine connections including:

- The base switch complex (BSC) with access to the Defense Communication System (DCS).
- The network management center (NMC).
- Technical control facilities.
- Various basewide emergency alarms.
- Several buildings.
- The pier.
- Video teleconferencing (VTC).
- A gateway to other activities beyond the base.

For this Appendix, parameters suggested by BITS system engineers at the Naval Computer and Telecommunications Command

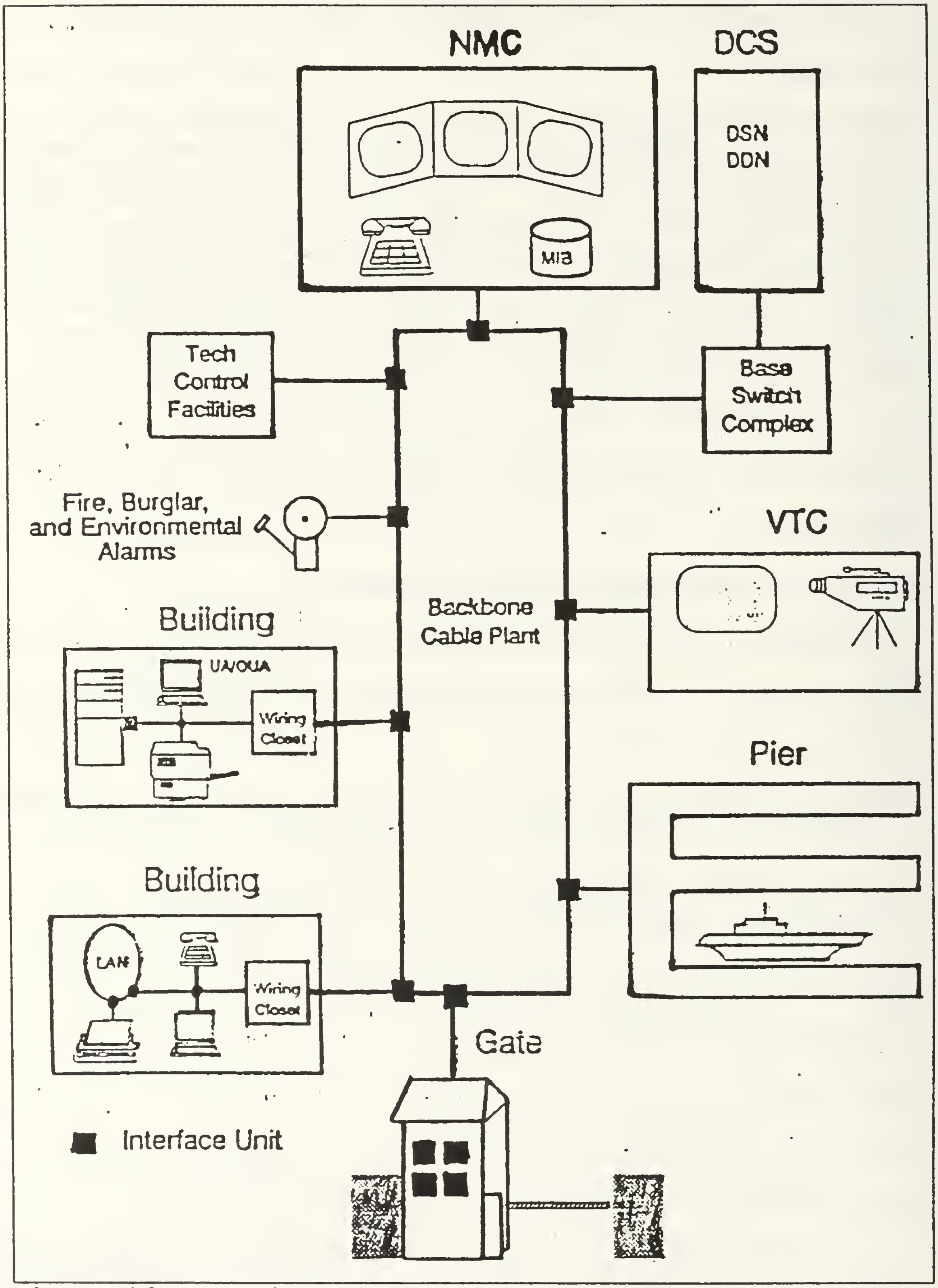

Figure 16. Generic BITS System

(NAVCOMTELCOM) and outlined in their Navy Base Communications Specifications [Ref. 15] are used.

1. Light Sources

For optical fiber communications systems, light sources must display specific characteristics. These include high efficiency, long life-time-in-use, reasonable low cost, sufficient power output, capability for various types of modulation, and physical compatibility with fiber ends [Ref. 35:p. 94]. Semiconductor diodes that produce light when a current is passed are the generally accepted light sources for fiber optic systems. These are of two types: injection laser diodes (ILDs) and light emitting diodes (LEDs). Lasers are much brighter, launch more power into a fiber, have a faster response, and its narrow line width increases maximum bandwidth availability which is crucial for high capacity, long haul systems. LEDs are generally used with multimode fibers.

For a typical Navy base configuration, the LED is the economically appropriate light source. Distances are intermediate vice long haul and choice of fiber, discussed later, is multimode. LEDs are of three basic configurations: edge, high-radiance (Burrus type), and surface emitters. Edge emitters use internal waveguiding to make emitted light more directional. Designers and manufacturers aim development at high radiance LEDs for communications systems, however,

because their structure demonstrates more efficient coupling into the optical fiber [Ref. 35:p. 95]. LEDs produce insignificant noise levels which are proportional to the information bandwidth and the number of transmission modes propagated in the fiber.

2. Light Detectors

The purpose of a light detector is to convert optical signals into electrical signals. Two types of semiconductor photodiodes, the PIN and the avalanche photodiode (APD), are commonly used.

Photodetectors must meet specific requirements to be effective. These characteristics include: high sensitivity at the light source wavelength, wide bandwidth or high speed response to track light intensity variations, small additional noise, stability over external conditions, and long life-times-in-use at reasonable costs. Photodiodes are described by four basic quantities: response time, quantum efficiency, total noise equivalent power and responsivity [Ref. 35:p. 120]. PIN detectors have lower responsivity and no internal gain and are usually used for small bandwidth systems less than 15 megahertz and short-length runs less than 500 meters. "APD's have high internal gains, high responsivity, fast response times and large gain-bandwidth products, with small active areas." [Ref. 35:p. 131] APD detectors are usually

used in situations where optimal noise performance is needed. Both detector types are useable in BITS.

3. Splices and Connectors

A fiber optics communication system is comprised of many components: sources, detectors, repeaters, devices, etc., that must be efficiently linked together to optimize the system. Splices, couplers and connectors are used to link these various components. Splices permanently join two fibers or two fiber bundles. Couplers link two or more fibers together providing two or more paths for the transmission signal. A connector links one fiber to another or to repeaters or to end devices in such a way that as much of the originally transmitted signal as possible is received. Connectors are usually removable from the rest of the optical fiber transmission system. Low cost, low loss, high strength, reproducibility, and reasonably simple installation and maintenance are factors to consider when choosing any linking mechanism [Ref. 35:p. 67-68]. T-couplers are commonly used. These devices (also called in-line data bus couplers and multi-fiber connectors) are three-port mechanisms that tap into a main bus. Because of losses introduced by T-couplers in a series, the maximum number of nodes using T-couplers is about ten. [Ref. 36:p. 58]

4. Modal Selection

Optical fibers are divided into two classes: single-mode and multimode with the latter sub-divided into two further types: step-index and graded-index. Single mode fibers have a very wide transmission bandwidth; several magnitudes greater than graded-index multimode. But because of a core radius of only a few micrometers, it is not easy to join such fibers without experiencing unwanted loss. It is very important that material for the cladding has the same high quality optical properties as the core. With multimode step-index fibers, handling is very easy because of its large core radius of up to a hundred or more micrometers. But its transmission bandwidth is very small, only a "few tens of megahertz over a kilometer." [Ref. 33:p. 122].

The best compromise between multimode and single mode fibers is the multimode graded-index. It has a core radius similar to step-index so it can be handled easily (easy splicing and connecting) but its transmission bandwidth is about a hundred times larger [Ref. 33:p. 122]. It can therefore carry more information by several orders of magnitude than the step-index fiber. Because rays within the core travel faster than in step-index fibers, it gives lower modal dispersion. And because its core radius is greater than single mode fibers, it does not require that light be launched into a very small core. For a BITS fiber optics system, the multimode graded-index (GRIN) fiber is the logical choice.

GRIN fiber with a core diameter of 62.5 um and a cladding diameter of 125 um are recommended by NAVCOMTELCOM engineers. The number of modes for the 62.5 um diameter fiber is approximately 849, therefore modal dispersion should be a factor in rise time calculations.

5. Modulation and Pulse Format

Most fiber optic communications systems are based on binary pulse code modulation (PCM). Current systems are more applicable to digital transmission than analog transmission for several reasons: signal regeneration at each repeater can be accomplished with a minimal amount of generated noise, analog signals are more susceptible to noise and signal distortion, and the frequency division multiplex equipment used for analog systems is more expensive than the time division multiplex equipment used for digital transmission. "The use of PCM with light source intensity modulation is relatively insensitive to noise since only the absence or presence of pulse energy is detected." [Ref. 35:p. 111]. The choice of pulse format is an important design feature for digital systems. Pulse formatting assigns fixed voltage levels to represent binary ones and zeros [Ref. 37:p. 91]. Mandated by Navy specifications, Nonreturn to Zero (NRZ) is the choice format for a BITS fiber optic system.

C. ANALYSIS OF DESIGN

Once system specifications are set, the basic engineering must prove to be sound. There are two major factors to consider for a fiber optic system: optical power requirements and rise time (dispersion) requirements. Calculations for both of these factors were accomplished to identify which one was the limiting factor. The generic BITS system in this study uses a closed loop bus topology. The longest link distance (D) was assigned a nominal value of 10 kilometers (km). Basic assumptions included the use of an LED, a GRIN multimode optical fiber, and an operating wavelength of 1310 nanometers.

1. Power Analysis

The power budget is a plan for allocating power to such components as connectors, splices, and optical fiber, and ensuring that a positive power margin exists for the designed 10 km link. It is necessary to determine how much light energy must be provided by the transmitter to overcome various system losses and still satisfy the energy input requirement [Ref. 36:p. 5]. Calculations are summarized in Figures 17 and 18 for a worst case scenario and a design objectives scenario. Obtained values are used to determine if this system is power limited. This analysis covers a system with both a PIN and an APD detector. The power budget was determined in the following manner:

a. Power Required at the Detector

As defined by the engineers at NAVCOMTELCOM, the following power is required at each of the specified detectors (P_d):

- PIN -38.0 dBm
- APD -43.5 dBm

The PIN detector requires more power at the detector than the APD. If the PIN detector meets system requirements, and there is enough power left to detect the signal, the PIN should be selected since it is less expensive.

b. Losses

To determine power requirements, it is essential to consider all losses involved within the system. The following apply:

(1) Input Coupling Loss. This loss occurs where the source light is introduced to the system from the LED. In this system, the input coupling loss (L_{ic}) is 1.0 dB. [Ref. 38:p. 18]

(2) Multi-fiber Connector Loss. In this example BITS system, T-couplers have been selected which have a worst case loss of 1.0 dB each and a design objective loss of 0.7 dB each. [Ref. 15:p. 38] Since each base that implements BITS will have unique needs, nine connectors have been chosen for this example, giving the system a total worst case connector loss (L_c) of 9.0 dB and a design objective loss of 6.3 dB.

FIBER OPTIC DESIGN ANALYSIS SUMMARY

WORST CASE SCENARIO

Fiber type: Multimode, graded index, 62.5 um core/125 um cladding

Operating wavelength (L)	1310 nm
Link or span length (D)	10 km
Maximum fiber attenuation rate (a)	1.0 db/km

POWER BUDGET SUMMARY

Detector type	PIN	APD
Power required at the detector (P_d)	-38.0 dBm	-43.5 dBm
Input coupling loss (L_{ic})	1.0 dB	1.0 dB
Multi-fiber connector loss (L_c) 1.0 dB per connector x 9 connectors	9.0 dB	9.0 dB
Splicing loss (L_{sp}) 0.5 dB per splice x 2 splices	1.0 dB	1.0 dB
Fiber loss (L_f = D x a)	10.0 dB	10.0 dB
Degradation margin (M_d)	10.0 dB	10.0 dB
Total loss (L_t), incl. degradation margin	31.0 dB	31.0 dB
Required power at source ($P_r = P_d + L_t$)	-7.0 dBm	-12.5 dBm
Typical power delivered by an LED (P_{LED}) (100 uW)	-10.0 dBm	-10.0 dBm
Link Margin ($M_l = P_{LED} - P_r$)	-3.0 dBm	2.5 dBm
Maximum Distance ($D_m = D + M_l/a$)	7.0 km	12.5 km

Figure 17. Power Budget Summary Worst Case Scenario

FIBER OPTIC DESIGN ANALYSIS SUMMARY

DESIGN OBJECTIVES SCENARIO

Fiber type: Multimode, graded index, 62.5 um core/125 um cladding

Operating wavelength (L)	1310 nm
Link or span length (D)	10 km
Fiber attenuation rate (a)	1.0 db/km

POWER BUDGET SUMMARY

Detector type	PIN	APD
Power required at the detector (P_d)	-38.0 dBm	-43.5 dBm
Input coupling loss (L_{ic})	1.0 dB	1.0 dB
Multi-fiber connector loss (L_c) 0.7 dB per connector x 9 connectors	6.3 dB	6.3 dB
Splicing loss (L_{sp}) 0.3 dB per splice x 2 splices	0.6 dB	0.6 dB
Fiber loss ($L_f = D \times a$)	10.0 dB	10.0 dB
Degradation margin (M_d)	10.0 dB	10.0 dB
Total loss (L_t), incl. degradation margin	27.9 dB	27.9 dB
Required power at source ($P_r = P_d + L_t$)	-10.1 dBm	-15.6 dBm
Typical power delivered by an LED (P_{LED}) (250 uW)	-6.0 dBm	-6.0 dBm
Link Margin ($M_t = P_{LED} - P_r$)	4.1 dBm	9.6 dBm
Maximum Distance ($D_m = D + M_t/a$)	14.1 km	19.6 km

Figure 18. Power Budget Summary Design Objectives Scenario

For an average-sized base, nine is a high number of connectors, but to err on the side of caution ensures that future needs can be satisfied with minimal upgrades to BITS.

(3) Splicing Loss. There are two splices in the link, one at either end of the LED. Using the worst case loss of 0.5 dB and the design objective loss of 0.3 dB, there was a link splicing loss (L_{sp}) of 1.0 dB and 0.6 dB, respectively.. Per BITS design specifications, splicing or connector loss is reduced by the requirement to cut the fiber to the desired length between nodes. This reduces the number of extra splices or single fiber connections needed to connect shorter precut fiber lengths to span a larger link. [Ref. 15:p. 36-38]

(4) Fiber Loss. This loss is dependent upon link length and maximum fiber attenuation rate. This system is initially designed for a maximum 10 km fiber link. Design specifications for BITS allows an attenuation loss value ranging from 0.5 to 1.0 dB/km. [Ref. 15:p. 38] For both scenarios the worst case upper limit of 1.0 dB/km was chosen, thus the fiber loss (L_f) is 10 dB.

(5) Degradation Margin. This margin (M_d) was specified by the NAVCOMTELCOM engineers to be 10.0 dB (worst case). Military standards call for a positive margin of at least 6.0 dB (design case) [Ref. 36:p. 75]. This margin accounts for losses over time for component aging, the effect

of varying temperature on light sources and detectors, backhoe loss (fiber breaks and repairs), and for manufacturing tolerance.

c. Power at the Source.

Power delivered by an LED (P_{LED}) ranges from 100 uW (-10.0 dBm) (worst case) [Ref. 39:p. 729] to 250 uW (-6.0 dB) (design case) [Ref. 40:p. 290].

d. Link Margin and Maximum Distances.

The power at the source minus the system losses (including degradation margin) must be at least equal to the power required at the detector for the system to be viable.

$$P_d <= P_{req} - \text{Losses}$$

Link margin (M_l) for the power budget is calculated by subtracting the power delivered to the detector from the power delivered from the LED. Maximum distances (D_m) without repeaters is calculated by adding the original designed link distance (D, or 10 km) to the value of the link margin divided by the fiber attenuation rate (a).

2. Rise Time/Dispersion Analysis

Once power requirements have been met, the system rise time must be calculated to determine whether or not the components are able to respond fast enough to handle the given signal data rates. Calculations are summarized in Figures 19 and 20 for the digital video case (70 Mbps) [Ref. 39:p. 898] and for Data Signal Rates capable of carrying up to 139.264

DIGITAL RISE TIME SUMMARY

Input data signal rate (R_e)	Digital video	70 Mbps
Optical line rate ($R_o = R_e$, for NRZ)		70 Mbps
Optical transmitter (Source)		LED
Spectral linewidth (L_l)		50 nm
Bandwidth-distance factor (B_d)		1000 MHz-km
Material dispersion coeffient (d_{ma})		0.006 ns/(nm x km)
Bit error rate (BER = $1 \times 10^{-11} \times D$)		10^{-10}
Allowable rise time ($t = 0.7/R_o$)		10.00 ns

Source (LED) rated rise time (t_t)		4.0 ns
Detector rated rise time		
APD (t_{r1})		0.5 ns
PIN (t_{r2})		1.0 ns
Rise time due to material (Chromatic) dispersion		
$t_{ma} = d_{ma} \times L_l \times D$		3.0 ns
Rise time due to fiber modal dispersion		
$t_{md} = 350 \times D/B_d$		3.5 ns
System rise time		
$t_{calc} = 1.1\ (t_t^2 + t_r^2 + t_{ma}^2 + t_{md}^2)^{0.5}$	APD	6.76 ns
	PIN	6.80 ns
Margin for system rise time (M_t)	APD	3.2 ns
Maximum distance (D_{max})	PIN/APD	17.6 km

Figure 19. Digital Rise Time Summary (Digital Video)

DIGITAL RISE TIME SUMMARY

Input data signal rate (R_e)	DS4N4	139.264 Mbps
Optical line rate ($R_o = R_e$, for NRZ)		139.264 Mbps
Optical transmitter (Source)		LED
Spectral linewidth (L_1)		50 nm
Bandwidth-distance factor (B_d)		1000 MHz-km
Material dispersion coeffient (d_{ms})		0.006 ns/(nm x km)
Bit error rate (BER = $1 \times 10^{-11} \times D$)		10^{-10}
Allowable rise time ($t = 0.7/R_o$)		5.03 ns

Source (LED) rated rise time (t_t)		4.0 ns
Detector rated rise time		
APD (t_{r1})		0.5 ns
PIN (t_{r2})		1.0 ns
Rise time due to material (Chromatic) dispersion $t_{ms} = d_{ms} \times L_1 \times D$		3.0 ns
Rise time due to fiber modal dispersion $t_{md} = 350 \times D/B_d$		3.5 ns
System rise time $t_{calc} = 1.1\ (t_t^2 + t_r^2 + t_{ms}^2 + t_{md}^2)^{0.5}$	APD	6.76 ns
	PIN	6.80 ns
Margin for system rise time (M_t)	APD	-1.74 ns
	PIN	-1.78 ns
Maximum distance (D_{max})	PIN/APD	4.3/4.5 km

Figure 20. Digital Rise Time Summary (DS4N4)

Mbps (DS4N4). [Ref. 38:p. 9]

a. Maximum Allowable Rise Time

The maximum allowable rise time (t_{max}) when using an NRZ coding format is determined by an optical line rate (R_o), using the following equation:

$$t_{max} = 0.7/R_o$$

The larger the data rate, the less time allowed for system rise time.

The optical line rate (R_o) for a NRZ coded system is equal to the data signal rate (R_s). For BITS, the following North American data signal rates are desired:

- DS1 = 1.544 Mbps
- DS1C = 3.154 Mbps
- DS2 = 6.312 Mbps
- DS3 = 44.736 Mbps
- Digital video = 70 Mbps
- DS4N4 = 139.264 Mbps

[Ref. 15:p. 38], [Ref. 38:p. 9] and [Ref. 39:p. 898]

b. System Calculated Rise Time

To determine what the actual total rise time will be, we must consider the different components as follows:

(1) Source (LED) Rated Rise Time (t_t) is 4.0 ns [Ref. 41:p. 4]

(2) Detector Rated Rise Time (t_r) is 0.75 ns for an APD [Ref. 42:p. 4] and 1.0 ns for a PIN [Ref. 43:p. 4].

(3) Rise Time Due to Material (Chromatic) Dispersion (t_{ma}) is caused by the nonlinear aspects of refractive index with respect to transmission wavelength [Ref. 35:p. 14]. The speed of light through a fiber varies with refractive index, which itself is wavelength dependent. Light, having a wavelength at which the refractive index is lower, will travel faster than a light at a wavelength at which the refractive index is higher [Ref. 36:p. 20]. Rise time due to material dispersion (t_{ma}) is a function of the material dispersion coefficient (d_{ma}), spectral linewidth (L), and link length (D). We obtain a value using the equation:

$$t_{ma} = d_{ma} * L_1 * D$$

We have specifications for a material dispersion coefficient of 6.0 ps/(nm * km) (or .006 ns/(nm * km)) [Ref. 15:p. 38], spectral linewidth of 5 nm [Ref. 41:p. 4], and our distance is 10 km.

(4) Rise Time Due to Fiber Modal Dispersion (t_{ma}) is due to the differential time delay of propagating paths from different waveguide modes [Ref. 36:p. 79]. It occurs because light can travel different paths within the fiber core. These paths vary in length, and because of this, they will arrive at the detector at different times. Rise time due

to fiber modal dispersion is a function of distance (D) in km and bandwidth distance factor (B_d) in Mhz * km, equated as:

$$t_{md} = 350 * D/B_d$$

The bandwidth distance factor was specified to be 1000 Mhz * km. [Ref. 15:p. 37]

c. Calculated Rise Time

After computing the individual contributors to system rise time, the squares of each factor are added, and the square root of the sum is determined. Once that is done, it is multiplied by a factor of 1.1 to obtain the calculated system rise time.

$$t_{calc} = 1.1 * (t_t^2 + t_{r2} + t_{ma}^2 + t_{md}^2)^{0.5}$$

This value must not exceed allowable rise time or the system is not viable, as it will be dispersion limited.

d. Link Margin and Maximum Distance

Rise time link margin was calculated by subtracting the calculated rise time (t_{calc}) from the maximum allowable rise time (t). Maximum distance for each data rate can then be determined by solving the above calculated system rise time equation for the distance (D) and substituting in the various values for maximum allowable rise time (t_{max}) for the calculated system rise time (t_{calc}) value.

D. SUMMARY

1. Basic System

The fiber optic system analyzed is a 10 km closed loop bus with nine nodes or subsystems (e.g., local area networks). The optical source is a light emitting diode (LED) with an operating wavelength of 1310 nanometers, using a graded index multi-mode optical fiber (65.5/125 micrometer core/cladding diameter), and either a APD or PIN detector. The basic conclusion, in most cases, is to use the PIN detector.

2. Power Conclusions

The use of a PIN detector in the worst case scenario resulted in a -3.0 dBm margin, which translates into a maximum distance of seven kilometers. This negative margin can be easily corrected with the use of the higher powered military specified 250 uW LED (-6.0 dB) vice a nominal 100 uW LED (-10.0 dB). This action would result in a positive margin of 1.0 dBm, which translates into a maximum distance of 11 kilometers. The 3.0 dBm negative margin could also be corrected with the use of the APD because it is more sensitive and requires less received signal power. The use of the PIN in the design objective scenario yields a +4.1 dBm margin, which translates into an achievable total distance of 14.1 kilometers.

In summary, the proposed BITS system analyzed in this study is not power limited. If distances greater than 14

kilometers are desired, then three factors must be considered: (1) obtain an LED with increased output power. LEDs can deliver up to approximately 1 milliwatt (0 dBm), (2) obtain a PIN detector that requires less received signal power or replace it with an APD, (3) reduce the amount of losses over the fiber link, such as reducing the number of T-connectors or obtaining a fiber that has a lower attenuation rate (dB/km), like the single mode fiber. However, the use of a single mode fiber will require the decision-maker to consider the use of different optical sources and detectors.

3. Rise Time/Dispersion Conclusions

A positive margin was obtained for all data rates except for the 140 Mbps DS4N4. As the data rate increased, the maximum allowable rise time for the DS4N4 channel fell to approximately 5 nanoseconds, whereas the calculated rise time was approximately 6.8 nanoseconds. This negative margin implies that the 10 kilometer system is rise time-limited for the DS4N4 data rate. In general, as the data rate increased, then rise time limitation become important. For this scenario, rise time limitation occurs for data rates above approximately 103 Mbps. If higher data rates are desired, then the link distance must be shortened. For the DS4N4 channel, the maximum distance before the use of a repeater is approximately four kilometers.

This system is not rise time-limited for the desired 70 Mbps digital video channel, and for this data rate, both rise time and power limitations are important considerations for link distances of 14 to 17 kilometers. It is also not rise time-limited for lower data rates, and in general, the system tends to be more power limited for longer distances at data rates for DS1 through DS3.

To obtain positive rise time margins for longer link distances then the following should be considered: (1) decrease the data rate, (2) obtain optical sources and/or detectors that are more sensitive and display lower rise time dispersion characteristics, and (3) change to single mode fiber to eliminate modal dispersion. As stated earlier, the use of a single mode fiber will require the decision-maker to consider the use of different optical sources and detectors.

APPENDIX B. ACRONYMS

Acronym **Page**

A

ADP--Automated Data Processing 2

APD--Avalanche Photodiode 96

APR--Agency Procurement Request 36

APTS--Activities Providing Telephone Service 3

ASDP--Abbreviated System Decision Paper 36

ASN RD&A--Assistant Secretary of the Navy for Research, Development, and Acquisition 41

AUTODIN--Automated Digital Network 18

AUTOVON--Automatic Voice Network 18

B

BAFO--Best and Final Offer 37

BCA--Base Communications Assessment 75

BCS--Base Communications Specifications 60

BITS--Base Information Transfer System 2

C

C4I--Command, Control, Communications, Computers and Intelligence 10

CBCO--Consolidated Base Communications Offices 64

CCC--CINC Command Complex 11

CDRL--Contract Data Requirements List 37

CIM--Corporate Information Management 25

Acronym **Page**

CINC--Commander in Chief 11

CINCLANTFLT--Commander in Chief, Atlantic Fleet 56

CLIN--Contract Line Item Number 37

CNO--Chief of Naval Operations 39

CO--Commanding Officer 2

COTR--Contracting Officer Technical Representative . . . 37

COTS--Commercial Off The Shelf 16

D

DASN (IRM)--Deputy Assistant Secretary of the Navy for Information Resource Management 9

DCS--Defense Communication System 17

DDN--Defense Data Network 18

DISA--Defense Information System Agency 23

DISNET--Defense Integrated Secure Network 23

DMS--Defense Message System 7

DOD--Department of Defense 18

DON--Department of the Navy 15

DSN--Defense Switched Network 23

E

E-mail--Electronic Mail 1

ECP--Engineering Change Proposal 38

ER--Efficiency Review 74

F

FIP--Federal Information Processing 76

Acronym **Page**

FIRMR--Federal Information Resources Management Regulation 53

FOC--Full Operational Capability 38

FTS 2000--Federal Telecommunications System (Year 2000) . 24

G

GLOBIX--Global Information Exchange System 11

GRIN--Graded Index 98

GSA--Government Services Agency 36

I

ILD--Injection Laser Diode 95

IOC--Initial Operational Capability 38

IS--Information System 26

ISDN--Integrated Services Digital Network 7

ITAC--Information Technology Acquisition Center 39

L

LAN--Local Area Network 1

LCM--Life Cycle Management 26

LED--Light Emitting Diode 95

LTOP--Lease to Purchase 49

M

MENS--Mission Essential Needs Statement 28

MILNET--Military Network 23

MTA--Message Transfer Agent 25

N

NAVCOMPT--Navy Comptroller 65

Acronym **Page**

NAVCOMTELCOM--Naval Computer and Telecommunications Command 2

NAVSEASYSCOM--Naval Sea Systems Command 56

NAVSUPSYSCOM--Naval Supply Systems Command 39

NCCA--Naval Communications Control Architecture 4

NCTS--Naval Computer and Telecommunication Station . . . 44

NCTAMS--EASTPAC Naval Computer and Telecommunication Area Master Station, Eastern Pacific 40

NCTAMS LANT--Naval Computer and Telecommunication Area Master Station, Atlantic 40

NCTAMS MED--Naval Computer and Telecommunication Area Master Station, Mediterranean 40

NCTAMS WESTPAC--Naval Computer and Telecommunication Area Master Station, Western Pacific 40

NIF--Navy Industrial Fund 59

NISMC--Navy Information Systems Management Center 39

NLFS--Navy Leasing Feasibility Study 52

NMC--Network Management Center 17

NRZ--Non-Return to Zero 99

<u>O</u>

OMB--Office of Management and Budget 53

OSI--Open System Interconnection 15

OUA--Organization User Agent 25

<u>P</u>

PBX--Private Branch Exchange 56

Acronym	Page
PCM--Pulse Code Modulation	99
PIP--Program Implementation Plan	32
POA&M--Plan of Action and Milestones	43
POM--Program Objective Memorandum	36
PPBS--Planning, Programming, and Budgeting System	47
R	
RDT&E--Research, Development, Testing and Evaluation	26
RFP--Request for Procurement	37
S	
SDP--System Decision Paper	29
SOW--Statement of Work	60
SPAWARSYSCOM--Space and Naval Warfare Systems Command	9
STU-III--Secure Telephone Unit	58
T	
TADIXS--Tactical Data Exchange Systems	11
TCC--Tactical Command Center	11
TCP/IP--Transmission Control Protocol/Internet Protocol	18
TELSUM--Telecommunications Summary	71
TMD--Telephone Management Detachment	65
TMP--Telephone Modernization Plan	75
TSR--Telecommunications Service Request	71
U	
USNA--United States Naval Academy	42
V	
VTC--Video Teleconferencing	1

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